Read Measures of Radioactivity

CHEMISTRY

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Our Radioactive World

➤ RADIATION is a factor to be reckoned with from now on, whether we like it or not. The atomic disintegrations already set in motion spontaneously or by the action of cyclotrons and atomic piles must march on relentlessly, each through its individual transformation series. The rate of disintegration can in no way be affected by any chemical treatment. The radiations given off can be detected only by special instruments designed for the purpose. They may be deadly, but we are no more sensitive to them than is almost any other chemical molecule.

If a laboratory using radioactive products dumps contaminated waste into the sewer, sooner or later the disintegrating particles will find their way into the soil and into other people's water supplies. Water from such sources and food grown in such soil may take up radioactive material. These radioactive atoms may be of a kind readily absorbed by our digestive processes and built into the structure of our bones and tissues. Here they would continue to bombard us internally with alpha or beta particles or gamma rays, or combinations of them. The lifetime of the radioactive element may greatly exceed our own.

As a warning, then, if for no other reason, it is important for students to learn to use the instruments that detect radioactivity. There are other rewards than the negative one of just keeping out of its way.

The science of nuclear phenomena is just beginning. We have harnessed a force greater than fire in its possibilities for usefulness and for harm. It is imperative that we train young scientists to understand this force, and to use it wisely.

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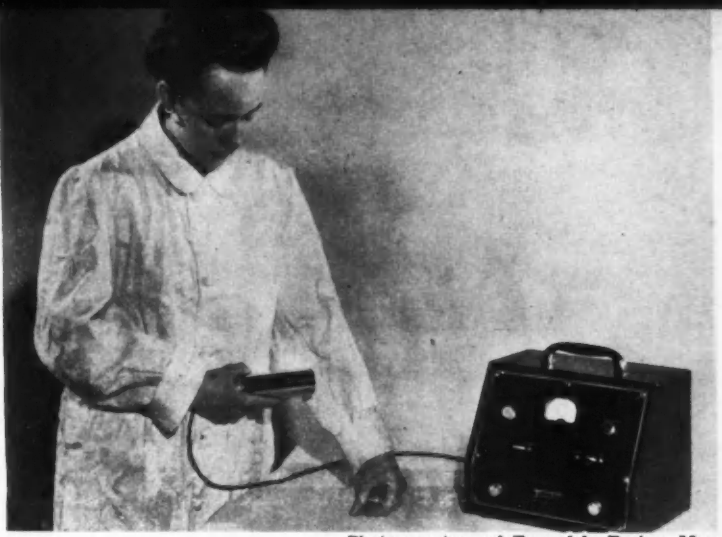


—Photo courtesy of Tracerlab, Boston, Mass.

➤ THE GEIGER COUNTER *has become one of the standard measuring devices for radioactivity, recording its presence by clicks or, as here, by the swing of a measuring needle. It is being used by this technician to find out whether her laboratory coat has become contaminated with radioactive material.*

Measures of Radioactivity

➤ IMPERCEPTIBLE to all our senses, the rays from radioactive atoms require instruments for their detection. These instruments are built to utilize effects of the radiations on other material. These give a result that we can see as flashes of light, hear as a difference in noise level coming through an amplifying system, or read on a dial through some indirect mechanism.

The direct effects of radiation are the ionization of the air they pass through, the blackening of photographic emulsions they reach, and scintillations of light from disintegrations and collisions of the actual subatomic particles.

These subatomic phenomena may be made visible by magnification and viewing against a dark background. They may be made audible by clicks which are the magnified reports of tiny discharges between oppositely changed poles in an electron tube—a kind of miniature thunder and lightning.

In the following articles, CHEMISTRY presents directions for some experimental procedures which will allow anyone without special expensive equipment to see for himself how radioactive materials are detected and measured.

Alpha Particles, Protons, Electrons Registered on Plates in Simple Experiments

Photographing Nuclear Particles

by Dr. J. H. Webb
Research Laboratories, Eastman Kodak Company.

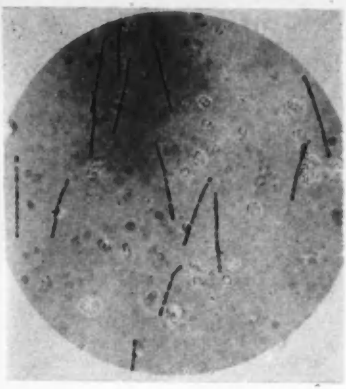
➤ Special photographic plates are now being marketed commercially by means of which individual nuclear events and the paths of charged nuclear particles can be registered and viewed with a conventional microscope. The plate is first exposed to particles from a radioactive source, the paths of the particles being marked by a trail of developable photographic grains in the emulsion. After developing, fixing, and washing in conventional manner, the tracks of the individual nuclear particles are viewed under a microscope.

A number of simple, but illuminating, experiments can be carried out with these plates that might be suitable for a high school class in physics. Some of the simpler types of experiments that could be carried out for this purpose are described below.

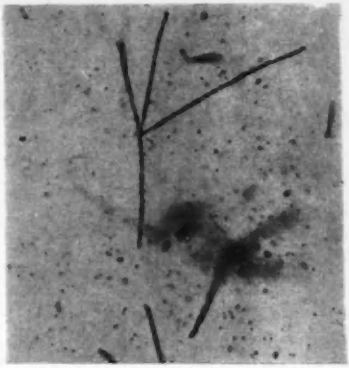
Experiments

1. *Tracks of Alpha Particles.* A very straightforward experiment consists in exposing the photographic plate directly to a weak source of polonium and registering the alpha particle tracks. Polonium is a naturally radioactive material giving up mono-energetic alpha particles of 5.3 million electron volts energy. These alpha particles have a path in air of about 4 cm. and will travel in straight paths in the emulsion leaving a trail of developable grains of 22 microns in length. A one-microgram source of polonium plated on a thin metallic base, if placed within 1mm. of the photographic emulsion for 30 minutes, will give numerous alpha particle tracks that can be viewed under the microscope with a magnification of 400 times. An illustrative picture of alpha particle tracks obtained in this way is shown in Figure 1.

2. *Thorium Star Tracks.* Another interesting experiment consists in registering several alpha particles emanating from a single thorium atom during the process of disintegration of this atom. The thorium atom disintegrates in steps by giving up a series of alpha particles and electrons over a long period of time. In this case, instead of the alpha particles entering the emulsion from an external source, the radioactive thorium is incorporated directly in the emulsion. The photographic plate is soaked in a solution of thorium acetate or nitrate (0.1 per cent by weight) for a period of 10 minutes, rinsed, dried, and then set aside in the dark for a time of about one week. It is then developed, fixed and washed in the regular manner. Such a plate is found, on microscopic examination, to contain throughout its depth numerous "radio thorium stars." An example of such a star is shown in Figure 2. The energies of



1. ALPHA PARTICLES *given off by a weak polonium source, exposed to the photographic plate for 30 minutes show up like this after the plate is developed and magnified 400 times.*

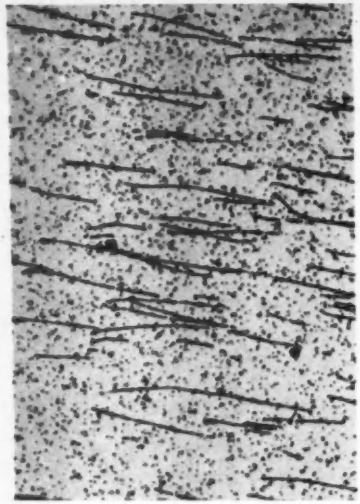


2. THORIUM STAR *tracks appear on plates which have been soaked in a solution of a thorium salt, dried and put away in the dark for about a week before development.*

the alpha particles given up by the disintegrating thorium atom are well known, ranging from 4.0 to 10 million electron volts. By measuring the lengths of the tracks of the alpha particles in a particular star, it is possible to determine the parent nucleus from which each alpha particle is emitted and hence the time order in which they occurred.

3. *Testing Radioactive Minerals.* An experiment that can be carried out readily with simple equipment is the registration of nuclear particles from radioactive minerals. A photographic plate placed within 1 mm. of a radioactive mineral, such as zircon, carnotite, monazite, or pitch blend, will register the tracks of alpha particles from the radioactive atoms contained in the mineral. This is a technique being used today in the exploration for uranium-bearing ores. Because of the short paths of alpha particles from naturally radioactive materials, only those radioactive atoms in the very surface of the mineral are effective. Therefore, the exposures must be extended to one or two weeks usually to obtain enough tracks after development for easy observation.

4. *Registration of Proton Tracks.* Present-day nuclear particle plates will register the paths of protons (nuclei of hydrogen atoms) as well as alpha particles, though the tracks are usually somewhat lighter in grain density. The usual method of obtaining proton tracks in an emulsion is to bombard the plate directly with protons from one of the high-energy accelerators such as a cyclotron. In absence of such equipment, however, there are other methods of obtaining proton tracks. For example, if a con-

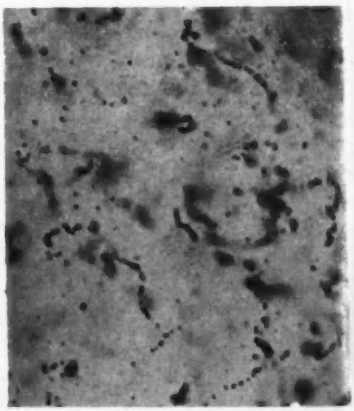


3. PROTON TRACKS *after a sixteen hour exposure, from a polonium source through an aluminum window. An enlargement of this illustration appears as the back cover picture.*

centrated polonium alpha particle source (about 5 millicuries) is covered with a 0.05-mm. thickness sheet of aluminum foil, the alpha particles will impinge upon the aluminum atoms and produce protons. The yield is low, there being produced only about one proton for each 100,000 alpha particles. However, if the polonium source, aluminum foil, and photographic plate are placed close together, enough protons can be obtained to give a number of proton tracks in the emulsion. Proton tracks obtained in a 16-hour exposure in this way are shown in Figure 3. These tracks were obtained with a polonium source of 10 millicuries, coated on a 5-mm. diameter copper disc, with the alpha particles impinging upon an aluminum foil window .025 mm. thick, and 3/8 inch in diameter, at a distance of 2 mm. from the polonium source. The photographic plate was placed in a sloping position 3-5 cm. from the aluminum foil. The energies of the protons to be expected range from 1.2 to 2.5 million electron volts on the average; however, it is possible to obtain tracks in this way for protons up to a maximum of about 6 million electron volts.

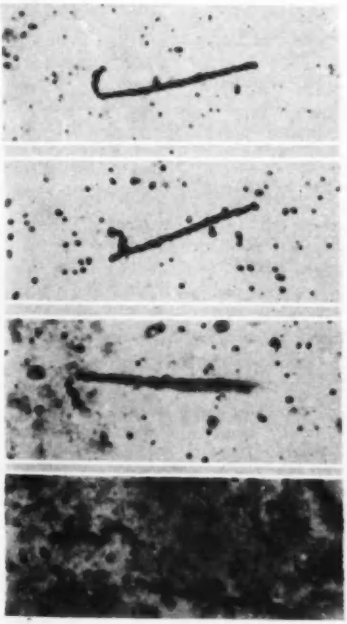
5. *Registration of Electron Tracks.* Nuclear track plates are now available that will register the tracks of electrons, through somewhat higher sen-

4. CROOKED PATHS *of electrons through the emulsion of special photographic plates made for the purpose. Radioactive material on the luminous figures and hands of a watch or clock will give off enough electrons to show tracks like this.*



sitivity emulsions are required than those used for the foregoing experiments with alpha particles and protons. Electron tracks in emulsions can be obtained in a variety of ways. a) The most direct method is to place one of the nuclear track plates directly in the electron beam of an electron microscope. Exposure to electrons of 25 to 50 kilovolts energy will result in many tracks in the emulsion that may be viewed after processing in the usual way. b) Another method of obtaining electron tracks is to expose the photographic plate to x-rays of 50 to 200 kilovolts energy from a conventional x-ray machine. Exposures should be given long enough to produce a barely visible density after development. The plate can be exposed inside its wrapping and cardboard container since the x-rays will penetrate these light materials. The electrons are produced in the emulsion by photoelectric ejection of electrons from the atoms absorbing the x-rays. The electrons in turn travel in crooked paths through the emulsion and leave a trail of developable grains in their wake. Tracks of electrons obtained in this way are shown in Figure 4. c) Electron tracks can be obtained by exposure of the photographic plate to a naturally ra-

5. NUCLEAR TRANSITIONS *among the decay products of uranium produce these tracks.*



6. ELECTRON EMISSION *from disintegrating thorium produced this typical star, with the electron's crooked path straggling down the plate.*

dioactive material such as radium, thorium, or uranium. One simple method of obtaining tracks of electrons is to expose a nuclear track plate to the radioactive numerals on a luminous dial watch or alarm clock. For this purpose it is better to remove the crystal of the clock or watch and place the plate directly in contact with the numerals. The light and alpha particles can be absorbed by interposing a thin sheet of tissue paper between the source and photographic plate.

Exposures

Exposures should extend from 5 min. to 1 hr. depending upon strength of source. The electrons will penetrate the paper to give tracks in the emulsion. d) Lastly, a very nice method of obtaining electron tracks is to record the tracks of electrons from individual radioactive atoms as was outlined for alpha particles in Experiment 2 above. Again, the emulsion is impregnated with uranium or thorium acetate (or nitrate) as described in Experiment 2. After being set aside for a week or two, the plate is developed, fixed, and dried, and then examined for electron tracks. Examples of electron tracks obtained in this way are shown in Figures 5 and 6 for the respective elements UX_1 and thorium. The long heavy track in Figure 5 corresponds to the alpha particle emitted in the transition from UI to UX_1. The light crooked track at the end of the alpha track corresponds to the emission of an electron from the UX_1 atom. Similarly, the crooked track shown emanating from the thorium star in Figure 6 corresponds to an electron emission during one stage of disintegration of the thorium atom.

It is to be strongly emphasized that experiments which involve the use of radioactive materials constitute a definite health hazard unless the experiments are carried out strictly in accordance with rules for the safe handling of such materials. It is therefore of great importance that experiments of the above described types be carried out under strict supervision and in accordance with proper safety rules such as outlined in the article, "Health Physics," published in *Nucleonics*, Vol. 3, p. 60, 1948.

Photographic Plates for Use in Nuclear Track Work

The types of photographic plates for carrying out the above experiments are available from the Eastman Kodak Company and can be purchased from regular Eastman Kodak Company dealers authorized to sell industrial products. For the above experiments, two standard types of plates are recommended. These are:

1) The Kodak NTA plate, size 1" x 3", thickness 25 microns, packaged in 1-dozen lots. These plates will register alpha particles from all naturally radioactive materials and protons up to 5 million electron volts. These plates are processed as follows: Develop for 2 minutes in Kodak D-19 developer at 68° F. temperature, wash for 10 minutes in running water at the same temperature, fix in plain 30 per cent hypo for twice the time for the plate to clear. These plates are recommended for the experiments, Nos. 1, 2, 3, and 4. The list price—$4.40 per dozen plus tax of 43 cents.

2) The Kodak NTB plate, size 1" x 3", thickness 50 microns, packaged in 1-dozen lots. These plates will register, in addition to alpha particles

and protons, electrons up to 100 kilovolts energy. These plates should be processed as follows: Develop in Kodak D-19 developer for 15 minutes at 68° F., wash for 10 minutes in running water at the same temperature, fix in plain 30 per cent hypo for twice the time to clear. These plates are recommended for the above outlined experiments, Nos. 5 a, b, c, and d. The list price—$4.40 per dozen plus tax of 43 cents.

Wetting Agents Slow Enzyme Activity

➤ NEW WEAPONS against disease and poor health can be expected when the riddle of enzyme action is solved. Latest development comes from England where in the laboratory of Donald Hockenhull of the Manchester College of Technology it was found that detergents or wetting agents will in general seriously decrease the activity of a liver enzyme. The results held true for a variety of wetting agents at different concentrations.

Enzymes are the vital chemical machines within the living cells that manufacture the compounds necessary for life, and there is much yet to be learned about how they operate. Each enzyme is thought to be able to select chemical raw materials from its surroundings and to hold these parts in place until the new compound has formed.

Many chemical processes, such as synthetic rubber manufacture, are speeded by the presence of a wetting agent. Therefore the contrary behavior of the liver enzyme shows that an entirely different type of process may be at work.

Thin Metal Films

➤ METAL FILMS, so thin that they can be used as supporting membranes for electron microscopic studies without showing visible structure, are made by an improved process which Dr. Nils Hast, of Stockholm, has reported to the editor of *Nature*, London.

The investigations described by him were carried out at the Nobel Institute for Physics in Stockholm. The metal film is made by evaporation in a vacuum of a small amount of beryllium or aluminum onto a liquid surface. In earlier methods the metals were evaporated onto a film of cellulose nitrate, or similar material, which then had to be dissolved away. With films made by this process, it sometimes happens that a faint structure appears in the electron microscope even if the film is very transparent.

In the improved process, Dr. Hast used several different liquids, but chiefly glycerol. The liquid must have a high boiling point and low vapor pressure at room temperatures. He covered a tiny piece of glass with glycerol and, after giving time for any water in this type of alcohol to evaporate, a small amount of beryllium or aluminum was evaporated. The coated glass was then put into a container into which distilled water was added. The glycerol was absorbed and the metal film floated to the water's surface.

Scientific Martyrdom Repeats Itself

Neutron Beams Cause Blindness

➤ THE HISTORY of scientific martyrdom is repeating itself. Five physicists are going blind because they looked unguardedly at the powerful neutron radiation from their atom smashers.

A half-century ago, when X-rays were new, other young and eager scientists also took chances with this novel radiation. Perhaps half a hundred of them (a meticulous count 12 years ago listed 27 by name) suffered the serious and horribly painful X-ray burns which developed into cancer. First a finger was lost, then hands and arms and finally life.

Happily, those wounded by neutrons are not martyrs in the strict sense of the term which implies sacrifice of life as well as health for a cause. And medical science can restore eyesight to them through operation for cataract and proper eyeglasses, though it could not restore lost fingers and hands to the earlier radiation martyrs.

The physicists sacrificed their eyesight in pioneer work on the cyclotrons. They were fired by the same zeal to speed the benefits of their powerful new tool as led men and women of an earlier generation of Americans to sacrifice health and life in perfecting X-ray equipment and technique for diagnosing and treating human ills.

Like the X-ray martyrs, the physicists took a calculated risk with neutrons. As early as 1935, the neutron beam from a cyclotron was known to be more dangerous than an X-ray beam. It has been known since the early days of the Manhattan District work on the atomic bomb that neutrons are four to ten times as dangerous as the same amount of X-rays. Yet the cyclotron pioneers used to watch for the violet-blue fluorescent beam of neutrons appearing. They deliberately looked into the beam, either from necessity while making repairs to the machine or out of curiosity over this new and powerful tool.

Neutrons, the sub-atomic particles that caused the eye damage, are the triggers of the atomic bomb, operating the chain reaction. Because they are electrically neutral they are very penetrating. With protons, neutrons make up the hearts of all atoms.

The lens of the eye is one of four tissues most sensitive to ionizing radiation, whether in the form of neutrons, X-rays or gamma rays from radium.

The other three are: 1. the white blood cells in the veins and arteries and bone marrow; 2. the male reproductive cells; 3. the cells lining the intestinal tract.

Even though the neutrons that caused cataracts in the lenses of the physicists' eyes must have hit other parts of their heads, the brain and other parts of the eye are very resistant to radiation so the men are not expected to suffer further damage.

Gas Ionization, Photography Reveal Radiation Phenomena

Radiation Detection Instruments

by H. D. Le Vine

Radiological Laboratory, Office of New York Directed Operations. Atomic Energy Commission.

Presented before the New York Safety Council

➤ The basic methods for alpha, beta and gamma measurements were worked out many years ago and actually few radically new methods have been devised, except that the work of physicists and engineers in the Atomic Energy program has rapidly advanced instrument and circuit design so that present day equipment is reliable, sturdy, and will retain calibration in a satisfactory manner.

The most commonly used devices today are those which depend upon gas ionization phenomena or the blackening of photographic emulsions. Up to the present time workers detecting radioactivity have devised methods that can measure physical change which results from the bombardment of gases, liquids and solids by radioactive particles. Gas ionization has been measured by electroscopes, electrometers and vacuum tube circuits. Temperature rise due to energy absorption has been measured by bolometers and similar instruments; fluorescence by photocells and light meters; the blackening of photographic emulsions visually or by a densitometer; the ionization within diamonds and other crystals by counting circuits or observation of color change within the crystal.

Alpha, beta, gamma, neutron and other radiations differ in their capability to penetrate matter and to create ionization in matter. The degree of ionization that a radiation can produce depends, to a great extent, upon the velocity at which the particle is traveling or its ability to knock electrons or protons from matter that it strikes.

Alpha Particles

The alpha particle is a positively charged helium nucleus, i.e., one that has lost its two planetary electrons. When they are slowed down, alpha particles regain the two missing electrons and then become helium gas. Even the most energetic alpha particles can travel only 8 or 9 centimeters before they are completely stopped by air. A thin sheet of paper will block their passage. These particles have rather high energy, which may be as much as 7 M.E.V., and may produce approximately 200,000 ion pairs before they are stopped. The specific ionization becomes markedly greater as the alpha particles slow down. An alpha particle with a range of 7 centimeters will produce an average of approximately 2400 ion pairs per millimeter of air traversed at 15° C. and 76 centimeters pressure. An alpha particle of 3 centimeters range will produce an average of approximately 2900 ion pairs per milli-

meter of air traversed and one of approximately .5 centimeters range will produce an average of about 6000 ion pairs per millimeter of air traversed.

Beta Particles

Beta particles are high speed electrons that sometimes have energy levels up to about 10 M.E.V.; generally the beta particle energy level is less than 3 M.E.V. A beta particle with a 3 M.E.V. energy level will travel at very nearly the velocity of light and will produce about 4 ion pairs per millimeter of travel, whereas a 3 M.E.V. alpha particle will have a speed 1/25 that of light and will produce 4000 ion pairs per millimeter of travel. It is obvious that an alpha particle will produce much greater ionization than a beta particle, but, on the other hand, a beta particle with a 3 M.E.V. energy will travel about 13 meters through air before it is stopped, compared to 1.7 centimeters for an alpha particle starting with the same energy level. The beta particle does not travel in a straight line but straggles, wandering in its path.

Gamma Radiation

Gamma radiation is electromagnetic in character and has much greater penetration through matter than either alpha or beta. High energy gamma can penetrate more than a foot of lead, while low energy gamma is very much the same as the soft x-radiation generated at 200 kilovolts or less, which can penetrate only about 3/16" of lead. Gamma radiation itself does not ionize, but, in striking matter, its behavior is identical to the action of light on a photoelectric surface; photoelectrons are ejected. The gamma radiation is measured as a discrete amount of energy, the photon, and each photon will eject one or more photoelectrons from matter that it strikes, whether the matter be gas, liquid or solid. These photoelectrons, with a somewhat lower energy level than the gamma photon that created them, ionize matter and thereby produce effects equivalent to other particles.

Neutrons

Neutrons are uncharged particles and were not originally recognized as they produced no direct ionization. On striking materials that contain hydrogen, lithium, beryllium and boron, protons are ejected from the nucleus. These protons, which are positively charged particles, can ionize gases, liquids and solids. When detected, they may indicate the presence of neutrons.

We speak of fast, slow and thermal neutrons. Fast neutrons may have an energy level of about 50 M.E.V. or more and the protons ejected will have an energy level of about 10 M.E.V. Slow neutrons are those whose energy levels are about a few thousand electron volts. Thermal neutrons have an energy level of approximately .028 electron volts.

Neutrons may be generated when alpha radiation impinges on lithium, beryllium, boron, deuterium and other materials. On the other hand, when slow neutrons impinge on lithium and boron, they may cause the emission of alpha particles.

In the methods of measurement of radiation by gas ionization, one hears of Ionization Chambers, Proportional Counters and Geiger-Mueller

Counters. Each of these represents a different operating portion on the curve that relates the degree of gas ionization to the voltage between electrodes of a given configuration in the ionizing medium. When radiation ionizes gas molecules, electrons and positive and negative ions are formed. Since the negative ions which are formed almost instantaneously recombine with the nearby positive ions, negative ions cannot be collected efficiently and therefore we generally speak of positive ions and electron collection only.

The positive ions, being of great mass, move slowly in the electrical field in comparison with electrons, and thus, when it is possible, every effort is made to collect electrons rather than positive ions, except when electron collection may give an inaccurate result due to other ionizing radiation which may be measured.

Gas Ionization

To explain the gas ionization phenomena, we can consider a device which consists of a cylindrical cathode, a central wire anode, and a sensitive means of measuring voltage changes that appear on the anode. With no voltage between electrodes, any voltage changes appearing in the anode will be due to electrons striking the wire in a random fashion.

With the application of low voltage gradients to the wire, the electrical field in the space between the cathode and the anode will cause electrons to be accelerated toward the positively charged anode wire. The electron will give up its charge at the wire and create a voltage pulse that is directly proportional to the number of electrons arriving there and to the capacitance of the system since each electron will carry approximately 4.8×10^{-10} e.s.u.

Since the average alpha particle will create about 100,000 ions, the average beta about 1000 and cosmic radiation about 300 per 10 centimeters of path, the ratio of pulse heights developed in an ionization chamber will be about 3:10:1000.

Avalanche Effect

When the voltage gradient is raised and the conditions inside the gas system are correct, then each electron will be accelerated and will ionize additional gas molecules due to the high electrical field gradient. This ionization creates an avalanche effect, limited only by the positive ion sheath that tends to surround the anode wire. The pulses generated are still proportional to the intensity of the incoming signal.

Due to the cascade effect of the avalanche, the proportional counter will multiply each ionizing event and therefore this multiplication will result in a much higher pulse output for an ionizing event than would be expected in an ionization chamber where no amplification takes place. The difference in pulse heights is called gas amplification and may be a figure with a value of several thousand.

When the voltage gradient is increased still further, the avalanche of ionization is no longer impeded by the positive ion sheath, and, generally, all the pulses that result are about the same height. This Geiger counting region, in contrast to the ionization counting region and the proportional

counting region, when expressed in graphical form, plotting counts per minute versus impressed voltage, gives a fairly horizontal plateau that may extend as much as 300 or 400 volts. Beyond this plateau almost continuous discharge takes place without the presence of radiation.

Method of Detection

The choice of the detecting method used — ionization chamber, proportional counter or Geiger counter — is determined by what the instrument is expected to do and the sensitivity of the measuring device which is to be used in conjunction with the detecting device. While the Geiger counter cannot distinguish between beta, gamma and cosmic radiation, the ionization chamber and the proportional counter can conveniently distinguish any of these from each other or from alpha.

Since an ionizing event may be repeated within a few microseconds, the system must be able to detect and measure a second event without interference from the operation of measuring the first event. This requires a system with a very short electrical time constant. The resolution of a detecting circuit is its ability to distinguish between two ionizing events that occur within a very short time of each other. This resolution is a combination of several factors, including the electrical capacitance of the circuit and the resistance between the electrodes. The time constant of the circuit is a product of the capacitance and the resistance; since very high resistance may be used occasionally, the time constant may be in the order of several seconds or minutes.

Since very small currents appear at the collecting electrode of ionization chambers, the measuring device should be either an electroscope, an electrometer or a vacuum tube circuit operating with low current drain on the measuring chamber. The vacuum tube circuits now available nullify the time constant of the ionization chamber circuit in spite of the high input resistance used. A small portion of the signal is fed back to the input circuit, which reduces the effective time constant to values permitting reasonable measuring accuracy.

Disintegration Count

When radioactive disintegration proceeds, the process is not one in which a uniform rate of disintegration results; rather, the fluctuations are statistical and the indicating device generally gives a reading that must be interpreted. If a low count is to be taken where a high background count exists, due to either contamination or natural radioactivity present, the total number of counts must be adequate to permit some statistical evaluation to be made. On the other hand, when one is counting material with high activity, the background could be ignored and the counting time reduced, although the total number of counts recorded should be adequate.

As a typical example of a low background count, procedures have been developed to permit measurement of the quantity of radon in the expired breath of persons who have ingested radioactive materials. The quantity of radon present in a one liter sample is generally in the order of microcuries. The rate of disintegration of the radon

a few hours or more after the expired air sample is taken may be as little as a few counts per minute, and since the background of a counting chamber may be equal to this rate of disintegration, a recorded count must be taken for 8 to 10 hours in order to secure a rate of disintegration to a degree of accuracy consistent with the requirements of the determination.

Window Density

Because the windows of the measuring devices may absorb all the radiation before it can enter the measuring area, in the case of the alpha and beta radiation, extremely thin window sections must be employed. Such windows are generally described as having a density of "milligrams per square centimeter" rather than as having a thickness and a density of material. Materials such as mica and low density plastic films less than .0006" thick are in common use. Glass wall counters .006" thick are also commercially available. Since the absorption of alpha and beta particles is mainly by collision with matter, a greater weight per unit of area would indicate the presence of a more massive quantity of matter to obstruct the passage of particles to be detected. With gamma and x-radiation the absorption is by K electron capture of the photons. The higher the atomic number of the material acting as an absorber for gamma and x-radiation, the greater is the absorption coefficient.

For the monitoring of personnel it is desirable to have the ionization chamber attached to the person's clothing. Considerable development has been made in pocket ionization chambers approximately the size of a fountain pen. These chambers are charged and read by an external device. They are very rugged and consist of a grounded cylindrical conducting electrode and a highly insulated coaxial wire. The chamber has a capacitance of a few micromicrofarads; the wire is charged up to about 150 volts. When radiation enters the chamber, the ionization that results reduces the voltage in proportion to the quantity of radiation. After the predetermined exposure time — one or more days, usually — the chamber is returned to the measuring circuit. The voltage change, based upon previous calibration, indicates the total dosage directly in roentgen units.

The pocket dosimeter is based essentially upon the same principle except that instead of a central insulating wire, a small electroscope and a capacitance is installed within the cylindrical electrode. The total charge and any subsequent voltage change are then read directly by observing the shadow of the quartz fiber of the electroscope on a scale which can be illuminated by placing the instrument so that a reasonably strong light shines into one end. An external charging box is required to bring the chamber up to operating voltage. These chambers are calibrated with gamma radiation and generally the scales are accurate within about $\pm$ 10%.

Recently pocket size radiation detection units have been developed using Geiger-Mueller counters that require a very low voltage polarizing source. These devices will sound

an alarm after having received approximately 50 milliroentgens.

One of the more successful commercial versions of a portable electroscope ionization chamber unit is the Lauritsen-Wollans instrument, which consists of a thin wall ionization chamber having discriminating devices to differentiate between alpha, beta and gamma, a time indicating device and a quartz fiber electrometer. The instrument is very light and is highly favored for field survey work.

Cutie Pie

The Cutie Pie is a hand-held survey meter that can distinguish between beta and gamma radiation and is used for checking high intensity sources. Its full scale range is 100 milliroentgens per hour for the most sensitive setting in the commercial model. This instrument has, however, been made with full scale sensitivity of 50 milliroentgens per hour.

The Zeuto is an excellent lightweight instrument for the detection of low level radiation. The electronic circuit consists of three tubes, two in a bridge circuit and the third in a feedback circuit to reduce the input time constant. This rate meter retains its calibration reasonably well.

The Zeus is similar to the Zeuto but has considerably less sensitivity. It also has the added feature of sliding aluminum and lucite screens, which allow differentiation between alpha, beta and gamma.

The family of proportional counters developed on the project includes several portable and semi-portable types. The most successful design is the Poppy, which soon will be commercially available. It can be used in conjunction with any one of a number of chamber designs which may be required for some particular application, such as the counting of alpha particles on the hands, using two flat chambers. Frequently a cylindrical probe is used to measure the alpha radiation present in orifices due to the deposition of dust. It is used mainly to check surfaces such as floors, walls, containers, table tops, etc., for contamination. The proportional counter is difficult to handle because of its instability at the operating point, which is on a steep portion of the characteristic curve. Slight changes in voltage may create large errors in the counting rate; difference of humidity and air pressure will cause the operating point to shift greatly.

Another type counter is called the Walkie Poppy, which consists of a power supply, an amplifier carried on the shoulder of the operator, and a small probe with a thin alpha permeable window on the end of a long cable. The operator uses earphones and can detect a few counts of alpha per minute by means of this instrument.

The Poppies Pop

The Poppies are so named because of the clicking or popping sound heard each time an alpha particle is located. Similarly, each of the instruments in the Atomic Energy Commission program has been coded on the basis of some one of its characteristics. For example, the Chang and Eng is actually a siamese dual ionization unit used for the measurement of neutron flux.

The Geiger-Mueller counter equipment consists of a power supply and

CURRENT TYPES OF INSTRUMENTS AVAILABLE

Instrument	Description	Range of Measurement	Manufacturer
*Pocket Ionization Chamber	Integrating ionization chamber	200 milliroentgens gamma	Victoreen Instrument Co. Instrument Development Laboratories
*Pocket Dosimeter	Integrating ionization chamber with built-in electrometer	200 milliroentgens gamma	Kelley-Koett International Corp. Cambridge Instrument Co. Instrument Development Laboratories Fred Henson, Inc.
Lauritsen-Wollans Electroscope	Rate meter ionization chamber with timing device	200-2000 milliroentgens per hour gamma; can read alpha and beta	Landsverk Electrometer Co.
Zeuto	Rate meter ionization chamber unit with electronic measuring circuit	6000-60,000 disintegrations per minute alpha; 40,000-400,000 disintegrations per minute beta; 4-40 milliroentgens per hour gamma	Victoreen Instrument Co.
*Zeus	Rate meter ionization chamber unit with electronic measuring circuit; can discriminate between alpha, beta and gamma	50,000-5,000,000 disintegrations per minute alpha; 250,000-25,000,000 disintegrations per minute beta; 25-2500 milliroentgens per hour gamma	Rauland Corp.
*Cutie Pie	Portable beta-gamma discriminating ionization rate meter	100-40,000 milliroentgens per hour gamma; can be calibrated for beta, approximately 400,000 - 40,000,000 disintegrations per minute	Sylvania Electric Products Co.
Poppy	Alpha proportional counter with various shaped probes; oral indication and meter	100-10,000 counts per minute	Raytheon Mfg. Co.
Handie Poppy	Alpha proportional counter with this probe	10-1000 counts per minute	
*Portable Beta-Gamma Count Rate Meter	Thin wall Geiger-Mueller tube in probe. Rate meter counting circuit	1000-100,000 counts per minute beta; .2-20 milliroentgens per hour gamma	Victoreen Instrument Co. Instrument Development Laboratories National Technical Laboratories

* Either commercially available at present or in the near future.

a rate meter unit used in conjunction with a probe type Geiger-Mueller counter tube. The instrument is light, portable, and is excellent for low counting rates. It tends to overload as the counting rate increases, but since its general application is for the detection of small quantities of beta and gamma radiation, it has enjoyed very wide use.

The Geiger-Mueller tubes are of interest since their application is considerably greater than just for use as portable probe units. Geiger-Mueller counter tubes are made in a variety of forms; some are cylindrical and require that the radiation impinge at right angles to the axis of the tube; others, used for beta measurements, have their windows placed so that the radiation must be parallel to the axis of the tube; still other types are used for dipping into solutions that are radioactive.

The original Geiger-Mueller counter tubes could not quench their discharge and therefore required external quenching means. More modern types of Geiger-Mueller counters in general use have vapors added to the noble gas filling. These are capable of quenching the discharge themselves. Since a portion of the organic vapors is destroyed during each quench period, the life of the tube is limited but still is quite adequate for continuous heavy work. These tubes may be used in conjunction with scalers. Scalers are frequently dividing units which record each count and integrate the total number of counts, either as a power of 2, i.e., having scales of 2, 4, 8, 16, 32, 64, etc., or as a decade device indicating the count in units, 10's, 100's, etc., either by interpolation or by direct reading methods.

Oxygen 14 Manufactured

➤A NEW KIND of oxygen has been manufactured and discovered.

A Princeton University team of scientists, Drs. R. Sherr, H. R. Muether and M. G. White, has reported to the American Physical Society meeting that by flinging the hearts of hydrogen atoms into nitrogen compounds it is possible to create a very short-lived variety of oxygen.

This is the sixth isotope of oxygen to be known. It is oxygen 14, which makes it just the same atomic weight as the commonest sort of nitrogen.

Both positrons (positive electrons) and gamma radiation are involved in the decay of the new kind of oxygen, which exists only about 76 seconds before it turns into an excited sort of nitrogen.

The other sorts of oxygen weigh 15, 16, 17, 18 and 19 times as much as hydrogen, lightest of the elements. Oxygen 16 is the commonest sort in the air we breathe. Nitrogen 14 is also in the air.

The man who first discovered how to cold-roll steel sheets and bars died just 50 years ago, 35 years after his discovery.

More than 2500 products use tin cans for packaging.

Mousetraps, Marbles, Tin Cans, Combs Used in Demonstrations

Simple Atomic Experiments

To understand atomic phenomena experimentation is necessary. In class room, home laboratory or less pretentious set-ups it is hardly practical to undertake large-scale experimentation with cyclotrons, piles or even most radioisotopes. But it is possible to obtain some conception of the mechanisms of atomic reactions and methods by simple experiments and demonstrations. Joseph H. Kraus, Science Clubs of America editor, has prepared a series of these simple experiments that anyone can do.

Chain Reaction by Mousetraps, Corks

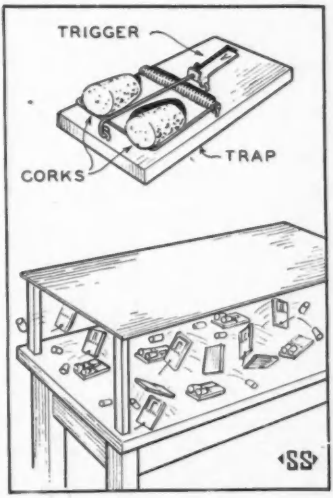
▶ A CHAIN reaction such as occurs in an atomic bomb where fissionable atoms are present in large numbers and are triggered by neutrons, may be represented by mousetrap "atoms" set with cork "neutrons."

It makes an interesting demonstration easily presented by any science student. Details of the arrangements are given by Richard M. Sutton of Haverford College in the *American Journal of Physics*.

Like an atom of uranium-235, a set mousetrap—the atom of the analogy—also has stored in it a lot of potential energy. Cork stoppers located on the spring arm represent the neutrons. If the trap is tripped it snaps, shooting the cork "neutrons" away violently in all directions.

Chain Reaction

If three or four dozen such traps are all set on the laboratory table and a cork is thrown into their midst, the chances are good that one or another trap will be set off. It now becomes extremely likely that this trap will spring other traps and a chain reaction takes place, resulting in "fission" of some of the mousetrap "atoms."



However, many of the mousetraps will not be sprung, corresponding to uranium atoms which have escaped the cascade.

With more traps and a greater "flux

of neutrons" a chain of higher probability becomes possible. The number of such cork "neutrons" which will strike the mousetrap "atoms" can be increased by placing a deflector, consisting of a sheet of wood or cardboard, over the pre-set traps.

Critical Size

It is pointed out that the relationship between partial explosion without the deflector and almost complete explosion with the deflector is closely linked with the conception of "critical size" in the atomic bomb.

If a still better mechanical representation of nuclear fission is desired, the writer recommends that the number of mousetraps be doubled. One trap should be placed on another so that the upper trap as a whole is flung up when the lower goes off. Now fission will be nearly complete with the mousetraps and corks flying in all directions.

But if even this analogy is not enough a further improvement is presented. The traps are set in layers six to eight inches apart on a "space lattice." The trigger of each trap is fitted with a rod hanging from it and passing through a hole drilled in the wooden base of the trap. Now the traps can be sprung when they are hit by cork "neutrons" either from above or below. Some of the corks will fall through the lattice and set off the "atoms" on the lower layers. About six layers of traps will make a good display.

Insert Barriers

The space lattice arrangement of mousetrap "atoms," Dr. Sutton says, also suggests an analogy with the nuclear pile in which fissionable materials are prepared and atomic energy is released under controlled conditions. If cardboard barriers are inserted between successive layers of traps, then the chance explosion of partial explosion of one layer will not affect adjacent layers. The barrier sheets serve to stop (but not absorb) the neutron-corks in much the same manner as boron rods regulate the reaction in the uranium-carbon pile by absorbing neutrons.

Atom-Smashing Shown With Marbles

➤ THE ATOMIC era, ushered in by the explosion of a single atomic bomb, the force of which was equivalent to 20,000 tons of TNT, will make us all think in terms of the tremendous power of the infinitely small. It was ability to split uranium atoms on a large scale that was responsible for the release of the terrific forces that destroyed Japanese cities.

Atoms, scientists believe, are built like miniature solar systems. The sun or suns at the center are thought to have a positive charge of electricity and are called protons. Around the "heart" or nucleus revolve small negatively charged particles called electrons. The electrons are held in their paths by the attraction between their negative charges and the positive charge of the atom heart. There are also other particles in the heart similar to protons, but without any electric charge. These are the neutrons.

A simple marble game illustrates what happens when a high-speed subatomic projectile bombards an atomic nucleus.

You can make this marble game yourself. Find or make a wooden "mound" shaped with a gentle slope as shown in the diagram. Hollow out a central crater large enough to hold a handful of marbles. Fill it with marbles to represent the heart of the atom that is to be split. There should be white marbles to represent neutrons, red marbles to represent protons.

Use More White Marbles

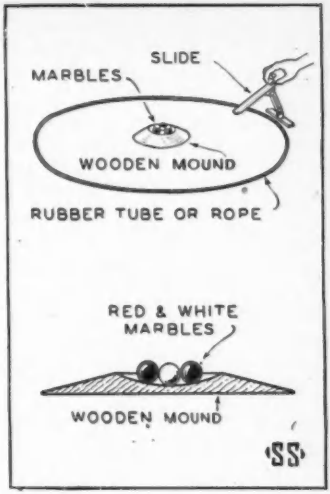
There should be more white marbles than red, since the heart of the uranium atom contains 92 protons, and the number of neutrons is 142 or more, depending on the kind of uranium.

The atom heart, of course, is not actually shaped like this and does not have a surrounding shell of wood or any other substance. But the slope of the mound will serve to hinder an attacking marble just as an atomic particle shot at the atom is held up by other forces or resistances.

Now you can prepare to attack your artificial atom heart. You need a trough on adjustable legs. A piece of what is known as "angle brass" will do nicely. The adjustable legs will allow you to regulate the speed of your attacking marble. For the attacker, use a larger marble to represent the speeding neutron used by the physicist to split the atom.

Roll a marble down the trough. It may go part way up the slope and roll down again at an angle, just as the physicist's projectile may bounce off the atom without disrupting it.

If you give your marble too much speed, it may go up the slope so fast



it will go on over the top of the crater without disturbing the marbles inside. This sort of thing may happen to the physicist's experiment, too. The speeding atomic projectile may go right on through the atom just as a comet can go right through the solar system without touching anything.

But if your marble has just the right speed and just the right amount of force, it will invade your artificial atom heart, and cause a complete rearrangement of the "protons" and "neutrons." Perhaps some of them will be knocked out altogether to roll down the slope and get together as a new, smaller atom or atoms somewhere else.

In the atom, the terrible force of this collision and the disruption of the atom produces heat. When this happens to millions of atoms, this heat is terrific.

Tin Can Electroscope for Radioactivity

► RADIOACTIVITY of soils and minerals may be measured with an electroscope made from a discarded tin can, sulfur and a few odds and ends. For super sensitivity a gold leaf is best. But very thin aluminum foil may be substituted. The instrument may be used as well for many other experiments in physics.

A tin container for mechanics' hand soap measuring about 3½ inches in diameter, 2¾ inches deep, forms the body. Cut a hole in the cover and bottom with an old-fashioned circular cutter, leaving a quarter-inch lip around the edge. Cut a one-inch hole in the side to accommodate the stopper. Best way to get a clean opening here is to drill a ⅝-inch hole and take the can to a radio shop or amateur radio enthusiast and request that the hole be cut through with a radio tube-socket punch.

Directly opposite this hole drill a smaller one for the bolt for attachment to the base which is a section of a large thread or small wire spool. Obtain two glass flashlight lenses from the auto supply store, or from a watchmaker who uses them as replacement crystals on clocks. Be sure that they will fit the can.

Sulfur Stopper

It is essential that the gold leaf be supported from a well insulated fitting. Sulfur is fine for this purpose. Locate a cork which will fit halfway into the hole in the side of the can. Remove it and wrap with one or two turns of writing paper. Tie paper with string, then remove the cork. Turn cork upside down. Fit cone bottom over cork barely to seal the bottom of the paper form. Put wood blocks outside to prevent tipping.

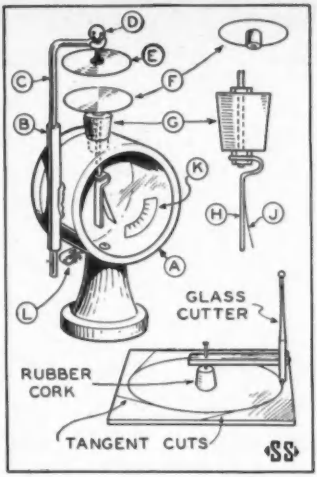
Pinch a pouring lip in the end of an old, clean tin can. Dump in some sulfur which you can get from the druggist in lump or powdered form. Heat ever so slowly. Have a metal lid or other cover handy to snuff out the flame should the sulfur take fire. Keep windows open just in case it does. Burning sulfur gives off choking fumes.

When sulfur is melted, pick the can up with pair of pliers or well protected hand and pour a small quantity into the paper form; let cool, then add the rest. Allow to cool. If you get the sulfur too hot it will darken, so keep heat very low and take your time. Don't spill any of the golden liquid on your fingers. Sulfur sticks like sealing wax and its burns are painful.

Strip the paper covering from the sulfur stopper. Water and sandpaper will help remove small bits and smooth the plug (G). Drill a hole through the center to accommodate an 8-32 threaded rod. This holds a bent brass or aluminum strip (H) which is 2 inches long and about a quarter inch wide, well rounded on its edges. Clamp between nuts as shown.

Ionization Area

A ten-cent sliding curtain rod supports the disk (E). This is grounded in use by being attached to the side of the can which in turn is connected to a ground wire through clip L. Temporarily set stopper G in position and bend the solid part of the rod so that the hole in the end of the rod comes directly over the center of the stopper,



while the vertical part falls alongside the edge of the can. Cut off a section of the tube part of the rod B and solder it to the side of the can or stick it on with celluloid cement. Clean paint from side of can with emery first to give good contact. If rod slides too easily squeeze the tube slightly with pliers for friction fit.

The two disks, E and F, are metal lids from two-piece variety home preserve jars. A threaded flat-head screw is soldered or cemented to the top of E. A loose nut or piece of tube is soldered or cemented to the under side of F for a slide fit. Ball D is a child's toy ball, kept in this position when the ionization area is in use. It has no purpose here but is used on top of the threaded rod in G when the electroscope is to be used without the ionization section which then is turned aside or removed. With shellac or celluloid cement fasten the glass disks to inside of can and its cover.

A single line of mucilage applied with a toothpick drawn across H close to its bend serves to attach the gold leaf or foil strip. Unless you have had some experience in handling gold foil, you had better ask a local window sign painter to apply the leaf for you. The strip is about a quarter inch wide and 1¼ inches long, secured only at the top. Aluminum or tin foil should be of the window sign painter's type. Most foils from gum, cigarette packages or candy are not thin enough for good results. Apply a paper scale (K) to the side of the glass.

Using Electroscope

Run a plastic comb through your hair, or rub a stick of sealing wax with a bit of fur or wool cloth. Immediately bring the comb or wax against disk F and draw across it slowly. The gold leaf will swing far out and maybe even into a horizontal position. You have applied a charge of the same sign to the metal disk, strip and leaf. Because like charges repel the leaf moves away. Gradually the leaf falls as the charge leaks off. In a well-made 'scope on a dry, cool day this may take as long as 24 hours. With a watch time the movement of the leaf between any two marks on the scale.

Strike a match and hold it near the plates. The leaf will fall rapidly. Hold match farther away and blow the hot air into the area between the plates without blowing out the flame. Leaf will drop away with each puff of air. This shows that the ionized air causes the charge to leak off.

Consult any good physics text for many other experiments which can be conducted with this delicate precision instrument.

Wire and Comb Charge Electroscope

➤ THE "ELECTRICITY in your hair," as popular version has it, is strong enough to charge a modified version of an electroscope—an instrument used rather extensively to measure among other things radioactivity and ionization of air. The instrument is of easy construction and is large enough so that results may be seen by an audience.

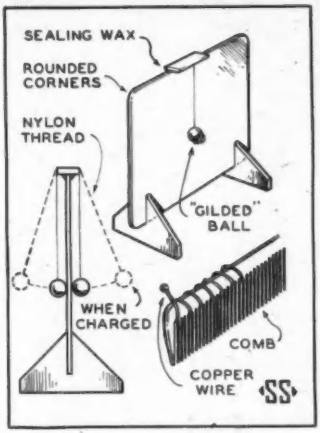
Obtain a heavy plate, preferably brass, copper or extruded metal, roughly about an eighth inch thick and four by five inches in size. Steel may be used if it is kept free from rust. Round off all corners and edges with a file and emery or sandpaper to make a perfectly smooth plate. Clean the surface if necessary.

Insulated Legs

Make two feet to fit this plate snugly. These should be cut by hack-saw preferably from a plastic sheet. A piece from a discarded plastic drinking tumbler, an old plastic box, or a plastic lipstick case, pencil lead box or similar article may be used.

Wash the plastic thoroughly in hot, soapy water, rinse and dry. Hacksaw two parallel cuts just far enough apart to accommodate the metal plate snugly and chip out between. It is better to make it fit tight than to have it loose. You can file or sandpaper the slots if they are too tight; shape the sides.

Push the plate into the feet and set them on a piece of sandpaper spread on a flat surface. By sliding the entire unit back and forth you will be able to wear off enough of the bottom of the feet to make the base level.



Light Ball

The ball which is to serve as the indicator of the demonstration electroscope may be made from any light material. It can be whittled from the pithy part of a dry cornstalk, the soft material inside a thick elderberry branch, or soft balsa. Shape roughly with a sharp knife and smooth with sandpaper. A larger table tennis or ping-pong ball may be substituted.

Attach a nylon thread to the ball with a tiny blob of celluloid cement and let it harden. If you do not have a spool of nylon thread you can tease a thread from a discarded stocking. Apply a thin coat of any metallic paint to the outside surface to make the ball conduct electricity. A small bottle of aluminum, gold or bronze will be satisfactory. This "paint" can be obtained from the local hardware or model supply store.

Gently warm a small piece of seal-

ing wax and mold between the fingers to form a slab which when fastened by pressure to the top of the plate will allow the ball to hang so that it barely touches the metal itself. Warm the wax with a match and imbed the thread from which the ball hangs so that the ball touches the center of the plate.

Two balls may be used if you like. In that case both may be hung from the same thread straddling the plate as shown.

Comb Charger

A plastic, celluloid or hard rubber comb will make a good rod with which to charge the plate. For best results bare a length of ordinary copper bell wire. Tie several knots closely together near one end to produce a sort of ball effect; clip the short end close and squeeze it into the mass so that no point extends. Better yet, attach a metal ball from a lamp socket pull chain. Let the ball extend about a quarter inch beyond the comb and wind the bare wire around the back of the comb, preferably with a turn between every tooth for half the length of the comb.

Run the comb briskly through your hair being careful that your fingers do not touch the wire spiral. Immediately bring the ball close to the lobe of your ear. You should hear a weak, crackling sound as the spark leaps to your ear from the ball end of the wire. But your hair must be absolutely clean and dry. Any grease or lotion on the hair will spoil the result. If your comb is greasy, it must be washed and dried thoroughly before it will give good results.

Charging Electroscope

Static electricity is generated when you run the comb through your hair. The result is better on a cold, crisp day than in warm, muggy atmosphere. The charge is picked up by the copper wire spiral. When the knob end is touched to the metal plate the charge is transferred to both plate and ball. With a weak charge the ball will bounce away slightly when you touch the plate. Run the comb through your hair again several times and each time touch the plate.

When the charge on the plate is great enough the balls will extend far to the side; in fact, the nylon thread may stand out almost at right angles to the plate. The reason is that the charge on both plate and ball is the same. Because "like charges repel" the ball moves away from the plate.

If the plate is well insulated, if the edges are not too thin and are well rounded, the charge may remain on the ball and plate for hours. Touching the plate with the finger will discharge it. The ball drops instantly.

Bring the hand near the ball. This will cause ball to fly toward the hand, give up its charge, bounce back to the place to pick up another charge and repeat in rapid succession for many seconds.

Light a match near the charged electroscope. This causes the ball to drop faster because of the ionization of air, that is, the air becomes more conductive and the charge is dissipated more rapidly. Hold the match farther away, and blow toward it and the electroscope. You will find that you can blow the ionized air in the direction of the unit.

French Scientists Tell Nuclear Researches On "Adventures in Science" Radio Program

French Atomic Pile

Radio program presented Saturday, Jan. 29, 1949, 3:15 to 3:30 p.m. EST under the auspices of Science Service over the Columbia Broadcasting System.

DAVIS—This is Watson Davis speaking from Paris. In France as in the rest of the world, atomic energy is in the thoughts and conversation of almost everyone. Frenchmen today are proud that at a Parisian suburb there now operates the world's first atomic pile outside of English-speaking countries — at least so far as we know. It has been demonstrated again by this achievement that science is truly international and that what one group of scientists does can be done by others. This has significance for not only France and America but the world. The atom today continues to be the top science news of the world.

ANNOUNCER—For a first-hand report on atomic energy in France, listen now as Columbia presents Adventures in Science with Watson Davis, director of Science Service and editor of the Science News Letter. Who are your Adventures in Science guests today, Mr. Davis?

DAVIS—The leader in the French atomic energy program and one of his associates will tell the American public in their own words about their work and its significance. Dr. Frédéric Joliot-Curie is one of the great physicists of all time. He is Nobel laureate. He is Director of the Commissariat à l'énergie atomique — the French atomic energy commission. He is a French delegate to the United Nations Commission on Atomic Energy, but even more importantly perhaps for the progress of atomic science, Dr. Joliot-Curie is the scientist who made a series of signficant contributions to the understanding of atomic phenomena. In 1935 he, with his wife Irène, herself a great scientist, discovered artificial radioactivity. Before that time it was thought that only nature could split an atom. Then, in an epocal year, 1939, it was Dr. Joliot-Curie who, simultaneously with the great Niels Bohr of Copenhagen, demonstrated and confirmed the reality of the fission of uranium and the release of atomic energy. Shortly thereafter, Dr. Joliot-Curie made the significant observation that the splitting of an uranium atom by a neutron causes the creation of several other neutrons. This is the key to the atomic bomb and the chain reaction. Now, Dr. Joliot-Curie directs development of atomic energy for this country. He is the Lillienthal of France in this respect. Now that an atomic pile is operating in France, I think the first question that most people would like to ask you, Dr. Joliot-Curie, is: Is France going to produce an atomic bomb?

JOLIOT—That question has already been answered officially, Mr. Davis. The French representative at the United Nations has stated officially

in July 1946 that France has no intention of undertaking the production of an atomic bomb. The first objective of atomic research in France is investigation. We shall be producing isotopes for research and for medical use. We expect to add to our knowledge and the world's knowledge of atomic processes.

DAVIS—Do you look forward to atomic power being applied practically in France, Dr. Joliot-Curie?

JOLIOT—Certainly, because as you know France is a country which needs new sources of energy for its development.

DAVIS—Could you tell us about the atomic pile or chain reactor which is now operating at Châtillon?

JOLIOT—I should like to have Dr. Bertrand Goldschmidt, one of my collaborators, tell about the details of the pile. You know, Mr. Davis, this is the first of a series of piles that are planned.

DAVIS—What are you hoping to do with this first pile?

JOLIOT—First we are going to find out what is a pile. We are going to train our junior scientists and technicians to run a chain reactor. As we carry on our investigations, we shall be making some radio-elements for investigations and possibly medical use.

DAVIS—When is it likely that your atomic furnace will get going?

JOLIOT—In less than two years from now we hope. It will be a medium power pile of about one thousand Kilowatts while this present one will run at a few Kilowatts only.

DAVIS—I understand that the pile now operating uses heavy water to moderate or slow down the neutrons. Is the heavy water used the same material which you successfully kept out of the hands of the invading Germans, sending it across the Channel to England in 1940 with your collaborators H. Halban and L. Kowarski, where it was used for vital experiments?

JOLIOT—No, Mr. Davis, the amount we had then bought from Norway was too small. We have obtained more from that same country to use in the present pile. So you see, other countries in Europe than France have really helped make our pile here.

DAVIS—Where did you get the uranium for the pile, Dr. Joliot-Curie?

JOLIOT—The uranium used was obtained by France before the war from Belgium. It, too, was hidden securely from the Germans, part in France, part in Morocco.

DAVIS—Up until two years ago, Dr. Joliot-Curie, you were I believe director of all French scientific research and in 1946 you were appointed High Commissioner for atomic energy.

JOLIOT—That is correct, Mr. Davis, I was appointed to these positions by the Provisional Government immediately after the Liberation.

DAVIS—Your interests continue to be broader than merely that of atomic energy, I understand, Dr. Joliot-Curie.

JOLIOT—Yes, I am still professor at the Collège de France and get into my laboratories there at least two or three days a week. Our research there does not concern atomic energy but other important investigations in nuclear physics.

DAVIS—Our other guest today is one of the division heads of the French Atomic Energy Commission, a chem-

ist who is well known in the United States because he worked on the atomic energy project there. He is Dr. Bertrand Goldschmidt, who has been responsible for the chemistry aspects of the construction of the French pile. Dr. Goldschmidt worked before the war at the Curie Laboratory and after the German invasion of France, he escaped from the country and enlisted in the Fighting French Forces. He was assigned to the British Atomic Energy project, then a highly secret undertaking. He was sent to Chicago to work with the Americans who were discovering how to extract plutonium, and later he worked on the Canadian Atomic Energy project, directing the chemical end of it at Chalk River. Dr. Goldschmidt, suppose you tell us just what kind of atomic pile is the French pile.

GOLDSCHMIDT—It is a heavy water-uranium oxide pile of low power. It is the first heavy water pile in the world to operate upon the oxide instead of the metal.

DAVIS—What does the uranium in the pile actually look like?

GOLDSCHMIDT—It is a brown oxide that was compressed and heated at 1500 degrees Centigrade in hydrogen furnaces in order to give it the highest density possible. We had to make these furnaces ourselves whereas in America your scientists would have been able to buy them commercially.

DAVIS—Is all the uranium in the pile uranium 235?

GOLDSCHMIDT—Not at all. It is just natural uranium. We have not undertaken to separate any isotopes of uranium in France.

DAVIS—That answers in another way, Dr. Goldschmidt, the question of whether France is attempting to make atomic bombs, because you would have to make separations if you were. But in the operation of the pile some plutonium is made, isn't it?

GOLDSCHMIDT—That is true, Mr. Davis, but only about a milligram a day.

DAVIS—Well, isn't that a very small amount? How long would it take to get enough to make a bomb out of this pile?

GOLDSCHMIDT—It is difficult to answer that question in terms of days, Mr. Davis. About two million days would be required to produce two kilograms, which the Smyth report officially issued in America says is less than the amount necessary. That would mean our pile would have to operate 50 centuries before there was any possibility of a bomb.

DAVIS—Will your first pile produce enough radio-elements for your own use?

GOLDSCHMIDT—As Dr. Joliot-Curie said, we shall be making some radio-active elements but our pile will not produce nearly as large a quantity of isotopes as the Oak Ridge pile. We shall welcome from America and other countries isotopes for more extended research and for industry and for curing disease. With the second pile we are now going to build, we hope to be quite independent with regard to our radio-isotope supplies.

DAVIS—What radio-elements will you first produce in the pile?

GOLDSCHMIDT—Probably radio-sodium and radiogold for medical use.

DAVIS—Is it likely that France will be able to produce its own uranium?

GOLDSCHMIDT—We have prospecting teams at various places in France,

Africa and Madagascar, and we have small plants to extract uranium from ore in France, at La Chaux, and in Madagascar. France's uranium ore is not nearly as rich as that in some other parts of the world but we do expect to produce our own uranium in the future.

DAVIS—You had charge of the purification of the uranium, didn't you?

GOLDSCHMIDT—Yes, that was done at an experimental plant 30 miles from Paris, at Le Bouchet. That is where we are now starting to produce pure uranium metal.

DAVIS—How much is France spending on atomic energy, Dr. Goldschmidt?

GOLDSCHMIDT—Very little, relatively. Where you in America spend one dollar and the British 10 cents, we in France spend one cent. The Smyth report told us that two billion dollars were spent by the United States in making the atomic bomb. This amount of money in France would be roughly the total government budget of France for a year.

DAVIS—That gives another negative answer to the atomic bomb question in dollars and francs, Dr. Goldschmidt. I would like to know, Dr. Goldschmidt, what from your American experience you found most helpful in connection with your work. Is what you learned there helpful to you now?

GOLDSCHMIDT—Yes and no, Mr. Davis. I am now working on different problems. But the most important thing I learnt in America was the extreme importance of team work with enthusiastic young people, and we have succeeded in creating the same atmosphere here. When I worked with Dr. Seaborg in Chicago, there were 25 chemists in the plutonium group and Dr. Seaborg was the oldest among them. He was 31.

DAVIS—How old were you then, Dr. Goldschmidt?

GOLDSCHMIDT—I was then 30, Mr. Davis.

DAVIS—Dr. Goldschmidt, have you ever seen an atomic bomb explode?

GOLDSCHMIDT—Yes, Mr. Davis, I was invited as a French observer at Bikini and I saw those two bombs set off, and like all the other observers I was terribly impressed by the underwater burst and its tremendous mushroom of radioactive water.

DAVIS—Dr. Goldschmidt, I know that you have not made an atomic bomb and you do not intend to make one, but I would like to ask you as a scientist, would you know how to make an atomic bomb?

GOLDSCHMIDT—Surely not — I do not know more about the making of the bomb than anybody can find in the Smyth report, which explains only the broad principles of the bomb.

DAVIS—When in your opinion will atomic energy be applied industrially?

GOLDSCHMIDT—I can guess that perhaps the first important atomic energy application will come somewhat indirectly from the discoveries made with the uses of radioisotopes probably in biology and medicine.

DAVIS—Is there any chance, Dr. Goldschmidt, that atomic energy can be used in the future to supply the great lack of power in the world? For instance, could the Sahara Desert be made to bloom and feed the world

by using atomic power plants to purify sea-water and pump it for irrigation purposes into the desert?

GOLDSCHMIDT—This is somewhat a too precise question to answer yet. But when your great scientist Benjamin Franklin was asked what could be the uses of balloons that he had just seen fly in France for the first time at the end of the 18th century, he said: "what can you say of the baby who has just been born?" This time I think we can all agree that the baby is full of marvelous promises if we know how to bring him up and avoid his getting out of control.

More Scientists Big Need

➤ SCIENTIFIC problems which could be solved through the use of radioactive elements from atomic piles are stacking up simply because there are not enough trained minds and hands to work on them, declared David E. Lilienthal, chairman of the U.S. Atomic Energy Commission, at the annual meeting of the Ohio Farm Bureau.

"In the last two years the number of research projects in these biological and medical fields has roughly doubled each six months," he said. "If there were more scientists and technicians trained in the use of radioisotopes, the increase would be even greater."

For this reason, he continued, the Oak Ridge Institute of Nuclear Studies has undertaken a series of training schools, in which about a third of those attending are from agricultural research institutions.

Radioactive elements promise immediate benefits to the farmer in two ways, Mr. Lilienthal pointed out. Through their use as tracers, they can obtain hitherto inaccessible information about what happens to mineral nutrients like phosphates, both in the soil and in the plant, and thereby give dollars-and-cents returns both in fertilizer savings and in higher crop yields. Through use as stimulators of genetic changes, they may speed the breeding of better hybrid corn, better potatoes, perhaps even better cattle and hogs.

Direct action of radioactivity in promoting plant growth does not look so promising, Mr. Lilienthal added. Reports of enormous increases in vegetables obtained on Hiroshima's bomb-blasted soil by a Japanese truck farmer were true enough, he admitted; only the canny farmer had used five times as much fertilizer as his neighbors—which may have had something to do with the results. Also, there were other factors, such as the possible killing of soil pests by the heat of the blast, the addition of wood ashes from the burned buildings, and so on.

Careful checks made under controlled conditions in this country have failed to give any good ground for expecting crop increases through direct use of radioactivity in the soil itself.

Salt, used for centuries to preserve food, draws water, sugars, proteins, and other nutrients from the food so that the sugars may be fermented by certain desirable bacteria to form acids which, along with the salt, act as preservatives.

From Atomic Energy Commission's Fifth Semiannual Report

Nuclear Science Today

➤ TODAY's nuclear science and the atomic energy industry, which is growing out of this science, rest upon the fundamental experiments and deductions of early twentieth century physicists. Niels Bohr, Ernest Rutherford, R. A. Millikan, and others of that distinguished company worked out fundamental principles. A more numerous company experimented and observed, gathered data, and developed the detailed theory. All together their research rounded out a working base for the engineers who built the machines of the wartime atomic industry.

For further advance in the pure sciences, which must precede industrial application, it is necessary in these postwar years to keep a large and growing crew of physicists and chemists experimenting, gathering more data, and reflecting on the facts observed and recorded in order to secure new understanding of nuclear forces. It is this fundamental endeavor in the field of physical research that the Atomic Energy Commission is helping to support, in accordance with objectives and plans for the development of which the law holds the Commission responsible to the Congress and the President.

Why is it that Government today assumes such a prominent part in providing the facilities for physical research? The men of the first four decades of the twentieth century whose genius made possible the progress of the 1940's did not do their work in Government laboratories, with Government-provided equipment.

The reason for such large-scale Government aid is that the gathering of the data on the problems before the nuclear physicists and chemists of today requires the work of men in teams of large size and the use of very expensive instruments.

Though the main supports of research in the past continue to play a strong part, it is necessary for progress, at the speed required, to draw upon the resources of the Nation through the public treasury. To get further into the mysteries of nuclear structure and nuclear forces, the physicist requires not, as in the 1930's, laboratory equipment in $10,000 lots, but single machines of great cost, machines such as the multibillion volt particle accelerators the AEC is building at the Radiation Laboratory of the University of California ($9,000,000) and at Brookhaven National Laboratory ($3,475,000); machines such as the nuclear reactors nearly finished at Brookhaven ($21,600,000).

These facilities and their operating groups are at the disposal of university and industrial scientists. The Commission also finances a wide range of studies on campuses and in industrial laboratories using privately-owned facilities. Research work done on two-thirds of the forty-odd particle accelerators in the United States is

financed in whole or in part by the Commission.

The reason for this widespread and costly scientific fact-hunt basically is that our understanding of the atomic nucleus is today all too inadequate. Though we have learned how to obtain energy in quantity from the nucleus of the atom of uranium and plutonium, we do not know the origin of the forces which hold the atomic nucleus together and hence govern the release of energy. Scientists today can offer no completely satisfactory explanation of most of the properties they have found the atomic nuclei to possess — such properties as the spin of nuclei, or the strength of the magnetism that atomic nuclei have been shown to have.

New and better instruments are an indispensible key to progress in atomic and nuclear research. The nuclear scientists cannot directly observe what takes place in the atom or in its nucleus. From hundreds and thousands of individual clues, they must piece together a solution to the mystery of what goes on in the nucleus. They work by indirection, using ingenious methods and machines. For example, present knowledge of atomic structure stemmed from intensive work late in the 19th century with the optical spectroscope, an instrument which arranges the component parts of a beam of light in a rainbow-like pattern according to their energies.

Present nuclear theory is probably at about the same stage as was the theory of atomic properties and structure 70 years ago when the experimenters of the day had begun to gather facts about atomic energies by tabulating spectral lines. In another 20 to 35 years, the genius of Rutherford, Max Planck, and Bohr set up theories about the structure of the atom and fixed energy levels which were found to give meaning to the observed facts.

It is the hope that the data now being gathered will in the same way relate in the not too distant future to a fruitful theory of the atomic nucleus by the new interpreters who will come along.

The path to knowledge is not a superhighway. It is full of turns and switch-backs. Promising leads become dead ends. In the face of road blocks scientists search for byways, never knowing which valley — which new fact — will lead to the truth ahead. Always there is pressure for greater precision of measurement, more sensitive instruments, improved techniques. Most important of all is the scientist himself. From his vision and curiosity will spring the great technological advances of the future.

In 1948, the major part of the Commission's physical research funds was used to support work in physics, particularly nuclear physics, the design and construction of particle accelerators, design of research reactors, design and construction of radiation detection instruments, and the improvement of isotope separation methods by means of the mass spectroscope. The Commission has made adequate amounts of fissionable material available for non-weapon research and development work.

Nuclear Reaction Studies

In each phase of these research projects, scientists taking part aim at solving practical immediate problems and at accumulating data which are

helping the scientists of the future to reach new conceptions of the nature of the atom and the nucleus.

The most extensive field of data accumulation comprises the studies of what happens when the fundamental particles of the atom collide with one another or with the nuclei of varying forms (or isotopes) of the atoms of the 96 elements so far identified. Finding these facts is the purpose of the research work done with particle accelerators — synchrotrons, cyclotrons, betatrons, Van de Graaff generators, and linear accelerators — and with nuclear reactors, or piles.

There is much immediate purpose to these studies. Through them the scientists are building the complete record of the nuclear reaction cross sections[1] of more than 700 isotopes of the elements when each is struck by nuclear particles of varying energies: a description of great importance to the physicist and the engineer. For these technicians, the facts about nuclear reaction cross sections tell how and what materials to choose for the structural frame, the control rods, the cooling gases or liquids, and the shields of the nuclear reactors which we hope one day will light our homes, power our industry, and possibly drive ships and airplanes.

Of course, back of this and other immediate practical applications for nuclear reaction cross sections lies the use of data of this fundamental sort for the development of new theory of the structure and the behavior of atomic nuclei and their particles.

But for whatever purpose the scientists and engineers wish these data, the scientists must first collect them. The collection starts through the process of bombarding the nuclei of a target material with a beam of particles coming from one of the small or great machines of present-day nuclear research.

At present, the entities most useful for bombarding nuclei are protons, deuterons (hydrogen 2), tritium (hydrogen 3), helium 3, alpha particles (helium 4), gamma rays, mesons of several varieties, neutrons, and electrons. Since the type of nuclear reaction that occurs and the probability of its occurrence vary considerably with the energy of the bombarding particle, it is necessary to work over a great range of energies, say from one thousandth of an electron volt to several billion electron volts. Moreover, it is desirable for the energies of the bombarding particles in a given beam to be precisely known and to be monochromatic; i.e., all of the same energy. If the bombarding particle has a charge, the velocity or en-

[1] The term "cross section" is a very common one in nuclear science and engineering. It indicates to the physicist, chemist, metallurgist, or engineer working with nuclear reactors, the probability that a given nuclear reaction will take place. The cross section measures the size of the "bull's-eye" or nuclear target, which is an important factor in whether a "hit" or reaction occurs. But this is not the only factor; under similar conditions any one of several types of nuclear reactions may occur, each a definite percentage of the time. Scientists take care of this situation by assigning a cross-section value to each reaction. These values, which are determined experimentally, enable him to calculate the probable number of hits.

There are many types of nuclear reactions, such as an alpha-neutron reaction, a proton-neutron reaction, or a deuteron-neutron reaction. The symbol for an alpha particle is α; for a neutron n; for a proton p; and for a deuteron d. Thus, the three reactions mentioned would be written (α,n), (p,n), and (d,n). The first symbol represents the bombarding particle, the second, the emitted particle after the reaction has occurred.

ergy of the beam may be raised to any desired level by one of the various types of particle accelerators.[2] The neutron is chargeless so that it cannot be accelerated by a particle accelerator.

However, high energy neutrons are most readily obtained by using a particle accelerator to bombard a suitable target material with a charged particle such as the proton, deuteron, or alpha particle. The neutrons are emitted from the reaction between the bombarding particles and the target.

The nuclear reactor provides an abundant source of low energy neutrons for neutron bombardment. This very important tool for modern physical research is available only at the research establishments of the national atomic energy program. No universities or industries possess such machines.

The Commission has reactors now available for general research at the Oak Ridge National Laboratory and the Argonne National Laboratory. These facilities are open to men and women of industries and colleges and universities from any part of the country. Of course, much classified research of use in the development of the phases of the atomic energy program having to do with weapons and power production is carried on at these and at other reactors owned by the Commission as trustees for the American people.

Neutron Cross Sections

Scientists need to measure various cross sections of neutron-bombarded nuclei, since neutrons are released in nuclear reactors and by atomic bombs and are necessary agents in bringing about the great output of energy in these machines. To make possible these fundamental measurements, a variety of instruments have been developed or improved by the men of the atomic energy project during and since the wartime days:

A mechanical velocity selector or "neutron chopper" in use before the war was improved and used at the Argonne National Laboratory for making these cross-section measurements.

A second instrument in use at Cor-

[2] Cyclotrons, synchrotrons, and betatrons are particle accelerators employing large electromagnets to hold the paths of the charged particles being accelerated in closed or spiral orbits. These machines contrast with linear accelerators and Van de Graaff generators which do not employ electromagnets. In the latter the paths of the particles are straight lines.

A brief tabulation of the various types of machines in operation or in construction follows:

Type of machine	Maximum energy (million electron volts)	Precision of energy determination	Number of particles
ELECTRON ACCELERATORS			
Betatron	300	Fair	Plentiful
Synchrotron	300	Fair	Plentiful
PROTON, DEUTERON, TRITIUM, HELIUM-3, ALPHA ACCELERATOR			
Van de Graaff	12	Excellent	Plentiful
Cyclotron	20	Fair	Plentiful
Linear accelerator	32	Fair	Few
Synchrotron	350	Fair	Few
PROTON ACCELERATOR			
Proton synchrotron	10,000	Fair	Few

nell University before the war was used and developed further by scientists at Los Alamos and Columbia University. In this instrument, a burst of neutrons produced by a cyclotron is detected in such a way that the effect of neutrons of a particular energy range can be measured and studied.

A third instrument, called a crystal spectrometer, based on the property of certain crystals to reflect neutrons of specific velocities at specific angles, was developed for use with the research reactors at Argonne and Oak Ridge.

Still a fourth type of instrument sometimes called a "pile oscillator" and based on the change in the operating characteristics of a reactor when a sample of material is periodically inserted into and withdrawn from the nuclear reactor, is in use at Argonne and Oak Ridge.

A problem common to all these instruments is that of getting neutrons of nearly the same velocity to use as bombarding particles.

By the use of these four types of instruments and others, a whole new range of data bearing on nuclear cross sections is being accumulated. Development of these instruments and the technique for their use represents one of the solid advances of the past two years in nuclear physics.

Corals May Form Petroleum

➤ CORAL REEFS in distant waters may some day contribute to the petroleum supply — but not in time to help present shortages. It will be crude oil for future eons which may be hundreds of thousands of years from now.

It is the tiny animals that form coral reefs that are manufacturing the petroleum, drop by drop, the American Chemical Society was told by Professor Werner Bergmann of Yale University. Stony coral, he said, contains minute amounts of a wax-like substance which apparently becomes entrapped in the ever-growing reefs.

It would require only a relatively minor geological change to bring about a disintegration of the reef, and only a slight rise in temperature to liquefy the waxy material and bring it together.

It is not inconceivable, therefore, that some coral reefs of a very distant past have contributed to the formation of present-day petroleum, and that present reefs, such as the Great Barrier Reef near Australia, are accumulating material for the formation of petroleum in a very distant future.

The wax, which makes up about one-seventh of one per cent of the coral, consists largely of hydrocarbons and complex alcohols, chemicals similar to those in petroleum.

A ten-year study of more than 100 different species of lower forms of marine life has revealed that the fats of sea-dwelling animals contain an unusually high amount of unsaponifiable fats, or fats that can not be converted into soap by treatment with caustic alkali. As a rule, he stated, the more primitive the animal, the higher percentage of unsaponifiable material in the fat. This is an important fact, the biochemical significance of which is not yet clear.

New Health and Safety Problems Studied by Sanitation Experts

Radioactive Waste Disposal

➤ CATCHING *the problem early, before damage is done, the Atomic Energy Commission recently held a symposium on how to get rid of waste products, solid, liquid and gaseous, as well as dangerous radiation from industrial plants using radioactive material. At the meeting, held in Washington, D. C., men familiar with the problems already found in centers where nuclear reactors are working told their experiences to representatives of interested organizations.*

These included members of the American Water Works Association, the Federation of Sewage Works Associations, the Conference of State Sanitary Engineers, the Conference of Municipal Sanitary Engineers and representatives of the following Federal agencies: the Geological Survey, the office of the Secretary of Defense, the Department of the Navy, the Public Health Service, the Tennessee Valley Authority and the Weather Bureau.

Abstracts of some of the papers given at this meeting, which outline the general problems, together with some of the discussion, are given below. They give a picture of what the conditions are in this new "industry" of atomic energy, and the serious attention that is being given to coping with them.

Radiation, the Fourth R

by DAVID E. LILIENTHAL
Chairman, Atomic Energy Commission

➤ THE ATOMIC ENERGY Commission is the proprietor, as trustee for the people of the United States, and the operator of a very large industry, a new industry, and one that is unique. It is one of the very largest integrated industries in the world and it is certainly the newest, and, in the course of the operation of this industry for the production of materials that will sustain the chain reactions—plutonium and uranium 235—some very important waste materials arise. They are new in kind but they are not unique in the sense that every new industry and all existing industries have problems of a comparable or analogous character.

Some industrial wastes have been handled well at the outset but in many industries the problems associated with waste disposal have not been handled well at the outset. It is our earnest desire and our responsibility to seek to have this phase of our responsibilities well handled—as well as technical skill and energy and foresight at this stage can handle it.

For my part, I think the viewpoint with which problems of this kind, and others even more difficult need to be discussed with the American people is this: We have to learn to live with radiation.

This has become a kind of fourth R. We know something about radiation and a great many people have actually lived with it. There are men in the X-ray field who are entirely familiar with radiation, who work and live with it every day, but now, the magnitude of this problem of living with radiation has changed in such an order that it is almost a different kind of problem. Whereas people are familiar with an X-ray machine or 5 grams of radium and have learned how to handle them, within the pile at Oak Ridge there are radioactive substances the equivalent not of the total radium supply of the United States, which is in the order of 30 ounces, but of tons of radium.

The waste disposal problem is a part of this general business of learning how to live with radiation. The way we have learned to live with things before was to learn as much as we could about them; to keep our shirts on; not to get overly emotional or hysterical; not to escape from things by emotional outbursts. This is not the way we have acted in every instance. I am sure that the first tornado ever observed, certainly the first great fire and many natural phenomena, have led those who saw them to seek some kind of escape, usually in describing these things as magic.

Radiation is just as much a natural phenomenon as anything else. The fact that we have multiplied it by intelligence does not change that fact. I am sure there will be a good deal of shock, at first, as we get used to these facts. But I am sure also that just as we were able by our intelligence to conquer other things, we will conquer this as well. I am confident that by the application of such professional talents as you represent here and various other experts—the medical officers, the sanitary engineers, the water works engineers, the biologists, and so on—something very solid and sensible will develop.

The Lethal Dose

by Dr. Shields Warren

Director, Division of Biology and Medicine, Atomic Energy Commission

➤ The special waste disposal problems of the atomic energy industry are essentially the problems associated with ionizing radiation. We are dealing with types of energy that are recognized. The biological effects of them are known. (The problem is new because of the quantities involved rather than because of the substances involved. Two and a half pounds of radium are the result of fifty-odd years of work in isolating radium. The burst of an atomic bomb gives off radiation equivalent to that of hundreds of tons of radium, which gives some idea of the magnitude involved. The hazards of radiation have been learned from the experience of the pioneers in X-ray and from the experience of those working with radium.)

We are continuously being bombarded by ionizing radiation in the form of cosmic rays. Those who live in Baltimore or New York will get, in the course of their lives, according to calculations about 2 r of cosmic rays. Those living in the Mountain

States will get about ten times as much or perhaps 20 r. It is well to keep these factors in mind as a means of keeping our perspective when we are dealing with radiation hazards.

Radiation acts in two general ways; external radiation and internal radiation. External radiation is that which comes, for example, from the X-ray tube or from a source of radium or from an atomic pile. It affects either the body as a whole if there is no shielding or no focusing, or it can be made to affect only certain parts of the body by shielding and by the shape of the opening and the protection surrounding the X-ray tube.

Internal radiation hinges on several factors. The amount and character depend first on the quantity absorbed within the body. One of the very dangerous radioactive substances is plutonium, but if plutonium is swallowed only a very small fraction ever gets into the body. The bulk is insoluble and is not absorbed.

Secondly, the quality of the radiation, whether the particular material taken in is an alpha, a beta or a gamma emitter, or even in very rare instances an emitter of neutrons, is important.

Third, the point where the material goes is very important. Sodium diffuses widely throughout the body. If a small amount of radioactive sodium is swallowed, it will be distributed widely throughout the body so that a gram of deltoid muscle will contain about as much as a gram of lung or spleen. On the other hand, iodine is absorbed in highly selective fashion and roughly seven-eighths of the iodine that is absorbed in the body winds up in the thyroid gland. In a 150-pound man, the thyroid will probably weigh 15 to 18 grams. There is not only a concentration by virtue of the seven-eighths localized there, but a further concentration by virtue of the great disparity in size between the thyroid and the body as a whole.

A fourth factor of importance is the rate of excretion from the body. Sodium leaves almost as fast as it enters. Some of the fission products, radioactive strontium, and plutonium are deposited in bones and may remain there for a considerable period of time.

Fifth, the half-life of the material counts a great deal. A material such as fluorine, with 118 minutes of half-life cannot be in any ordinary quantities a serious radiation hazard. Radioactive carbon on the contrary may be present in minute amounts and even though its radiation is very soft, the fact that its half-life is 5,100 years means that the material maintains its full potency for as long as an individual lives and as long as any of the material remains within him.

Now, let's consider the effects of external radiation in more detail. In the first place, all types of radiation—alpha, beta, X-rays, gamma rays as from radium, or neutrons—act qualitatively in the same way. There are quantitative differences between them. There are differences in powers of penetration. But, from the standpoint of injury done to tissue, the injury done by one type of ionizing radiation is virtually the same as that done by another type of ionizing radiation.

There is a tremendous difference between the amount of radiation a person can take in the body as a whole and that which he can take in a

small part of his body. That helps reduce the danger from the absorption externally of most radioactive materials, because a good share of them tend to be concentrated in one or another of the body tissues.

On a field ½-inch square, a dose of 5000 r is not infrequently used to cure a small skin cancer. A scar will persist, but no harm is done. A tenth of that total given to the whole individual, would be enough to kill.

We are urged to get chest X-rays periodically and, if we have something wrong with our digestive tract, to take a gastrointestinal series. In the average gastrointestinal series the radiation is directed to the most important part of your body as far as the manufacture of blood and many of the vital organs are concerned and the total dose is roughly 40 r. Fortunately the body has a great recovery power. If less than the lethal dose of total body radiation is given, it will not have the same effect if it is spread over several applications that a single dose of the same amount would have. The rest period between allows for an appreciable degree of recovery. And it is perfectly possible to give a person a dose of 100 r each day on three successive days without any startling harm resulting, whereas, that same dose in the amount of 300 r would probably kill some out of a large group of people so radiated. About 400 r's would kill half the people who are radiated. This is called an LD-50, or a lethal dose sufficient to kill 50 per cent of the population receiving it.

There are also enormous differences in species. Paramecium swimming around in a green fresh water pond has a LD-50 of 300,000 r. If we radiate the population of paramecium, it would take about 300,000 r to kill half of them. In a population of the pupal stage of some insects, the LD-50 is about 150,000 r. In the rat, it runs somewhere between 825 and 900 r, and in the guinea pig, one of the most sensitive animals to radiation, it takes only about 250 to kill half of the population, and so on. Plants, in general, are far more resistant than are animals.

What are some of the problems that we have to face if fair amounts of radioactivity should get into, to take a very bad example, the headwaters of the Mississippi? In the first place, we come to the problem that much of the material placed in the water may become accumulated by certain biologic organisms. The oyster, for example, in the course of his life filters out of sea water enough calcium to make a very respectable shell that contains a number of grams more than his own weight of calcium. Perhaps there is eight times as much weight to the oyster shell as to the oyster. That is an example of the power of concentration of a specific material.

These biologic concentrations of waste materials have caused some degree of concern as to whether it might be conceivable, first to have concentration in algae, then in snails that live on the algae, then in fish that eat the snails—whether we could wind up with a concentration that would be dangerous to humans. To date experimental work indicates that that is not the case. However, a good deal of further research work has to be done on the subject.

To sum up the present situation

then, we can say that so far as external ionizing radiation is concerned, there is no hazard with proper methods of disposal; that from the standpoint of internal radiation, to the best of our knowledge, the precautions we are utilizing are giving adequate protection. The matter of concentration has to be worked out further, although the indications are that we are as yet within safe limits. We are striving for as near the ideal as possible; we would like to get as near zero output of radioactivity as we can attain. We have measuring devices that can detect activity at a level that will not be dangerous to humans. We have a means of knowing what our hazard is and of measuring that hazard.

We are not dealing with unknown hazards. We know, on the basis of experience, what the human body will stand without harm. Coming down from the other side, we know the probable fatal dose. We know that 100 r will do some, although very slight, harm, and that the least dose with which evidence of harm can be constantly detected in humans is about 15 r. We know that 0.1 r, not once but repeated over and over again, day in and day out, has not done harm.

Those working with radioactivity in the field of applied biophysics have succeeded in training people to work day after day with large amounts of ionizing radiations with such a degree of safety that they do not receive even this permissible dose, or even half of it except at great intervals.

MR. F. H. WARING (*Chief Engineer, State Department of Health, Columbus, Ohio*): What is the effect upon bacteria?

DR. WARREN: In general, bacteria are resistant. I have tried to sterilize cultures of bacteria and have gone up to 200,000 r. Viruses take well up into hundreds of thousands of r to have any effect brought about upon them.

I would say that there would be no conceivable amount of radiation discharged in a waste material that would alter the vegetative forms of the bacteria. They might alter the genetic character of the bacterium if the dosage ran up fairly high. This is a point that is under study at the present time and I cannot give you a clear-cut answer on that.

DR. WILLIAM RUDOLFS (*New Jersey Agricultural Experiment Station, New Brunswick, N. J.*): Did I understand you to say that there was no accumulation in fish food?

DR. WARREN: There may possibly be an accumulation in fish food because some of the algae will selectively pick up certain of the compounds. Some of the snails may feed on them, or some of the crustaceans, and finally get into fish. In general, any of the deleterious products that have been picked up have been stored, not in the part of the fish that is eaten, but largely in the skeleton of the fish.

In the fish at Bikini, for example, which had an opportunity to get large amounts of the fission products from the underwater blast, there was relatively little activity in the flesh of the fish as compared with the bones of the fish.

MR. FLOYD W. MOHLMAN (*Chief Chemist, Sanitary District of Chicago*): With regard to your statement

about the great concentration in the paramecium, is that selective? Does that acquire a higher concentration for water with a low concentration; and second, is there any danger from contact rather than ingestion?

DR. WARREN: There is no danger, so far as I know, from contact. In the various measurements that Dr. Donaldson and others have made, the level has not been made up to the level where there would be a contact danger. As far as the paramecium goes, the figure I gave was concerned with its resistance to radiation and not its power of concentration. It will concentrate in its vacuoles some material, some of the isotopic materials, but the degree to which it is concentrated has not been worked out. In other words, it has been done qualitatively but not quantitatively.

How Much Can We Take?

by DR. AUSTIN BRUES

Director, Division of Biology and Medicine, Argonne National Laboratory

I SHOULD LIKE first to take up the question of tolerances and to try to indicate from the standpoint of the physician and biologist how a tolerance is arrived at and what its significance is.

In the matter of external total body radiation, the tolerance now commonly used is somewhere in the vicinity of 0.1 r per day. Some authorities have suggested lowering that to 0.3 per week. This represents a daily or weekly amount of radiation which can be sustained indefinitely. An individual who is not ordinarily exposed to external radiation presumably can tolerate, without any deleterious effect that is detectable, somewhat larger amounts if they are given at a single time. This is quite true in the case of individuals who receive X-rays for diagnostic purposes, because several r units, are received by an individual who has a thorough-going examination of his abdominal organs by the diagnostic radiologist.

However, the daily tolerance has been rather carefully adhered to throughout the history of the Atomic Energy Project as a daily maximum, so that most of the individuals concerned with laboratory procedures worked part time at other types of work and did not receive regularly 0.1 r per day. Actually, by maintaining 0.1 r as the maximum value, very few individuals got near that dose.

The derivation of this value is perhaps of some interest. We would like to derive our values from what we know about the human response to external radiation.

For example, a great many radiologists, especially those who practiced in the earlier years before the dangers of external X-rays were fully recognized, developed certain changes such as atrophic changes in the hands and cancer of the skin of the hands. There are reports that certain diseases are commoner in radiologists than they are in other people. But, it is almost impossible to find out how much radiation these radiologists have received, either as individuals or on the average. The best we can say is that

it appears probable that those who have suffered injury have received amounts which are considerably greater, possibly by a factor of 10, than the tolerance amount considered safe for certain periods.

As a result we have to go to experimental work with animals to derive or justify our present tolerance values. Until rather recently the only visible biological effects, from external radiation of animals given daily throughout life was seen in the vicinity of 1 r a day, which may correspond to the amount that some radiologists received in former years. I think that 0.1 r was originally set up, on the basis of the fact that, since nothing below 1 r would produce detectable effects, one might introduce a factor of safety of 10. Some recent work has shown that in certain rather specific cases, such as the increase in size of the ovaries in mice given small amounts of radiation, detectable effects occasionally occur at 0.5 per day. Also, animal experiments have shown that 1 r per day in an animal may have possible effects on the life span. We are very interested in knowing but have no way of finding out whether such an effect may occur right down to the last quantum of radiation. The only answer we can give is that nothing is detectable in large numbers of animals in the vicinity of the tolerance range.

In the case of absorbed internal emitters we have better means of comparison between experimental work and the human instance than we have in the case of external radiation. A number of individuals have suffered late effects of the absorption of radium, particularly workers in the radium industry. At any rate, we do have data indicating how much radium is in the skeleton of a person who has suffered from these changes ten or twenty years after the time of exposure and we also have data on the amount of radium which may commonly be found in the skeleton of individuals who do not show any such changes. About 1 microgram of radium retained in the skeleton does, in a fair proportion of cases, produce degenerative changes in bones and latent bone tumors may occur. This gives us something very definite to tie to in the case of other radioelements.

In experimental work on animals considerably higher concentrations of radium in the bone are necessary in order to induce tumors in rats or mice or rabbits. The factor there is possibly 100, and for this reason it is fortunate that we have the data for humans. A probable reason for the difference is that radium is much more effective after a matter of decades than it is after a matter of years, and the life-span of animals is not measured in decades.

In deriving these tolerance values, we not only have a ceiling, which is the amount we know will produce deleterious effects, but we also have a floor, representing the normal amount of radioactivity present in an individual under natural environmental conditions. At least four radioactive materials are normally found in the human body, Carbon 14, Potassium 41, radium, and uranium.

There are two aspects to the question of the relation between radiation and health. On the negative side we

have the fact that late and remote effects can be produced by radiations, either by continuous low-level external radiation or by internally absorbed materials, and that these may occur under conditions where no physical defects are noted at the time of exposure.

Again, on the negative side is the fact that our very careful efforts to track this problem down and see that no damage is done and the fact that the atomic bomb is such a striking development, have made a public mystery of radiation which sometimes puts it in a different emotional category than other hazards, such as infectious diseases.

On the positive side of the ledger we have, first, the fact that the forms of radiation which are hazardous as isotopes or as external radiations are readily measurable, down to the amount which is worth considering as a hazard, and below. Secondly, probably much more thought has been given to this problem than to any other similar health problem.

Radioactive Studies of "Shots"

➤ BETTER RESULTS from medicines given by hypodermic injection may be had in the future as a result of studies with radioactive chemicals.

The studies, by Drs. Myron Prinzmetal, Eliot Corday, H. C. Bergman, Lois Schwartz and Ramon J. Sprintzler of the Institute for Medical Research, Cedars of Lebanon Hospital, Los Angeles, were reported recently in the journal, *Science*.

When they gave a "shot" of radioactive sodium into the muscles, half of it was absorbed in 30 minutes and almost 90% in one hour, they found. This period of time required for the chemical to be absorbed was much longer than would be expected from impressions gained in giving hypodermic injections to patients.

In the low blood pressure that follows shock from hemorrhage, absorption of radiosodium was slowed so that only about one-tenth as much of the chemical was absorbed in half an hour as was the case when blood pressure was normal.

The passage of radioactive chemicals through the chambers of the heart itself can also now be graphically recorded with a specially constructed ink-writing Geiger-Muller counter, the scientists announced. It is this counter which gave the information about absorption times of hypodermically injected radiosodium.

In the heart studies, the radiosodium is injected into one of the veins of the forearm and the radiocardiogram is made with a carefully shielded Geiger-Muller tube placed over the chest above the heart.

Since radioactive sodium has a short half-life of 14.8 hours and is rapidly eliminated by the kidneys, tiny amounts may safely be injected into the blood stream and allowed to flow through the heart. The amount of radiation with the dose given is much less than that which patients receive during various diagnostic X-ray examinations. More than 250 persons have been given injections without any bad results during the last year and a half.

Direct Experimental Measurement of The Fundamental Electrical Particle

The Charge of the Electron

A Classic of Chemistry

In this experiment Dr. Millikan, in a somewhat round-about way, achieved the direct measurement of the electric charge on tiny ionized particles in rarefied air. He measured the rate of fall of his oil-fog droplets with gravity and the rate of their rise against gravity in an electrical field of known strength. Allowing for the effect of friction of air on the moving droplets, and knowing their density, he could calculate the radius of each individual one. From this he could calculate the drop's weight.

With this much known about individual drops, he could calculate the electrical charges they carried. What he found was that the charges he measured were integral multiples of one quantity. This common divisor he found to be about 4.69 x 10^{-10}. Later refinements have modified the figure a little, so that it is now taken as nearer 4.8 x 10^{-10}. The startling thing about the determination is its proof that there are "atoms" of electricity as well as of matter.

A New Modification of the Cloud Method of Determining the Elementary Electrical Charge and the Most Probable Value of That Charge. *By Prof. R. A. Millikan. In the London, Edinburgh and Dublin Philosophical Magazine and Journal of Science. Vol. XIX, February, 1910.*

➤ Among all physical constants there are two which will be universally admitted to be of predominant importance; the one is the velocity of light, which now appears in many of the fundamental equations of theoretical physics, and the other is the ultimate, or elementary, electrical charge, a knowledge of which makes possible a determination of the absolute values of all atomic and molecular weights, the absolute number of molecules in a given weight of any substance, the kinetic energy of agitation of any molecule at a given temperature, and a considerable number of other important physical quantities.

While the velocity of light is now known with a precision of one part in twenty thousand, the value of the elementary electrical charge has until very recently been exceedingly uncertain. The results herewith presented seem to show that the method here used for its determination — a modification of the Thompson-Wilson cloud method — furnishes the value of *e* with a directness, certainty, and precision, easily comparable with that obtained by any of the methods which have thus far been used, the error in the final mean value being not more than 2 per cent. Furthermore, with the use of a chronograph in place of a stop watch for taking time intervals, the method is perhaps capable of a slighty greater accuracy than has yet been given to it.

As is well-known, H. A. Wilson's modification of Thomson's cloud method of determining e consists in observing first, the rate of fall under gravity of a cloud produced in an ionized fog-chamber by a sudden expansion, and second, the rate of fall of a like cloud when a vertical electrical field is superposed upon gravity. . .

The outstanding causes of uncertainty in Wilson's method, as used by ourselves, were as follows:

1. There is an experimental difficulty involved in obtaining clouds which fall without any distortion of the upper surface because of air currents.

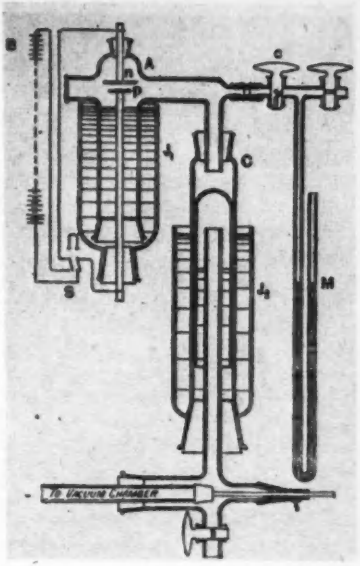
2. The upper surface of a cloud falling in an electrical field is exceedingly difficult to follow on account of the scattering of the cloud which is usually produced by throwing on the field.

3. The method necessitates the assumption that it is possible to obtain in successive expansions exactly identical drops, so that r_2 and v_1 can be used as though they applied to the same drop.

4. The assumption is made that the cloud falls uniformly, and that there is no appreciable evaporation during the time of observation.

5. The assumption is made that the temperature of the air through which the cloud falls is the equilibrium temperature after condensation —a quantity obtained from theoretical considerations relating to the adiabatic expansion of saturated vapours and the experimental curve expressing the relation between the temperature and density of a saturated vapour.

The results obtained by the method herewith presented are freed from all of these sources of uncertainty. . .



➤ BETWEEN *the plates of this apparatus, Dr. Millikan saw the minute clouds formed in ionized gas, disperse into star-like points of light which he proved to be drops carrying from two to six electrons.*

My original plan for eliminating the evaporation error was to obtain, if possible, an electric field strong enough to exactly balance the force of gravity upon the cloud and by means of a sliding contact to vary the strength of this field so as to hold the cloud balanced throughout its entire life. In this way it was thought that the whole evaporation-history of the cloud might be recorded, and suitable allowances then made in the observations on the rate of fall to eliminate entirely the error due to evaporation.

It was not found possible to balance the cloud as had been originally planned, but it was found possible to do something very much better; namely, to hold individual charged drops suspended by the field for periods varying from 30 to 60 seconds. I have never actually timed drops which lasted more than 45 seconds, although I have several times observed drops which in my judgment lasted considerably longer than this. The drops which it was found possible to balance by an electrical field always carried multiple charges, and the difficulty experienced in balancing such drops was less than had been anticipated.

The procedure is simply to form a cloud and throw on the field immediately thereafter. The drops which have charges of the same sign as that of the upper plate or too weak charges of the opposite sign, rapidly fall, while those which are charged with too many multiples of sign opposite to that of the upper plate are jerked up against gravity to this plate. The result is that after a lapse of 7 or 8 seconds the field of view has become quite clear save for a relatively small number of drops which have just the right ratio of charge to mass to be held suspended by the electric field. These appear as perfectly distinct bright points. I have on several occasions obtained but one single such "star" in the whole field and held it there for nearly a minute. For the most part, however, the observations recorded below were made with a considerable number of such points in view. Thin, flocculent clouds, the production of which seemed to be facilitated by keeping the water-jackets J_1 and J_2 a degree or two above the temperature of the room, were found to be particularly favorable to observations of this kind.

Furthermore, it was found possible to so vary the mass of a drop by varying the expansion, or the charge carried by a drop by varying the ionization, that drops carrying in some cases two, in some three, in some four, in some five, and in some six, multiples could be held suspended by nearly the same field. The means of gradually varying the field which had been planned were therefore found to be unnecessary. If a given field would not hold any drops suspended it was varied by steps of 100 or 200 volts until drops were held stationary, or nearly stationary. When the P.D. was thrown off it was often possible to see different drops move down under gravity with greatly different speeds, thus showing that these drops had different masses and correspondingly different charges.

The life history of these drops is as follows. If they are a little too heavy to be held quite stationary by the field they begin to move slowly down under gravity. Since, however, they slowly evaporate, their downward motion presently ceases, and they become stationary for a considerable period of time; then the field gets the better of gravity and they move slowly upward. Toward the end of their life in the space between the plates, this upward motion becomes quite rapidly accelerated and they are drawn with considerable speed to the upper plate. This, taken in connection with the fact that their whole life between plates only 4 or 5 mm. apart is from 35 to 60 seconds, will make it obvious that

during a very considerable fraction of this time their motion must be exceedingly slow. I have often held drops through a period of from 10 to 15 seconds, during which it was impossible to see that they were moving at all. Shortly after an expansion I have seen drops which at first seemed stationary, but which then began to move slowly down in the direction of gravity, then became stationary again, then finally began to move slowly up. This is probably due to the fact that large multiply-charged drops are not in equilibrium with smaller singly-charged drops near them, and hence, instead of evaporating, actually grow for a time at the expense of their small neighbors. Be this as it may, however, it is by utilizing the experimental fact that there is a considerable period during which the drops are essentially stationary that it becomes possible to make measurements upon the rate of fall in which the error due to evaporation is wholly negligible in comparison with the other errors of the experiment. Furthermore, in making measurements of this kind the observer is just as likely to time a drop which has not quite reached its stationary point as one which has just passed through that point, so that the mean of a considerable number of observations would, even from a theoretical standpoint, be quite free from an error due to evaporation.

The observations on the rate of fall were made with a short-focus telescope T placed about two feet away from the plates. In the eyepiece of this telescope were placed three equally spaced cross-hairs, the distance between the extreme ones corresponding to about one-third of the distance between the plates. A small section of the space between the plates was illuminated by a very narrow beam from an arc-light, the heat of the arc being absorbed by three water cells in series. The air between the plates was ionized by 200 mg. of radium, of activity 20,000, placed from 3 to 10 centimetres away from the plates. A second or so after expansion the radium was removed, or screened off with a lead screen, and the field thrown on by hand by means of a double-throw switch. If drops were not found to be held suspended by the field the P. D. was changed or the expansion varied until they were so held. The cross-hairs were set near the lower plate, and as soon as a stationary drop was found somewhat above the upper cross-hair, it was watched for a few seconds to make sure that it was not moving, and then the field was thrown off and the plates short-circuited by means of the double-throw switch, so as to make sure that they retained no charge. The drop was then timed by means of an accurate stop-watch as it passed across the three cross-hairs, one of the two hands of the watch being stopped at the instant of passage across the middle cross-hair, the other at the instant of passage across the lower one. It will be seen that this method of observation furnishes a double check upon evaporation; for if the drop is stationary at first, it is not evaporating sufficiently to influence the reading of the rate of fall, and if it begins to evaporate appreciably before the reading is completed, the time required to pass through the second space should be greater than that required to pass through the first space. It will be seen from the observations which fol-

low that this was not, in general, the case.

It is an exceedingly interesting and instructive experiment to watch one of these drops start, and stop, or even reverse its direction of motion, as the field is thrown off and on. I have often caught a drop which was just too light to remain stationary and moved it back and forth in this way four or five times between the same two cross-hairs, watching it first fall under gravity when the field was thrown off, and then rise against gravity when the field was thrown on. The accuracy and certainty with which the instants of passage of the drops across the cross-hairs can be determined is precisely the same as that obtainable in timing the passage of a star across the cross-hairs of a transit instrument.

Conclusion:

1. The temperature of the fog chamber a very few seconds after expansion in the form of apparatus shown in the figure is essentially the temperature of the room.

2. The balanced drop method herewith presented for the determination of e involves an experimental error of not more than 2 per cent, and is entirely free from all theoretical uncertainties except such as are incident to the application of Stokes' law to liquid spheres of diameters varying from 30 to 50 times the mean free path of air molecules.

3. The results obtained by this method taken in conection with Rutherford's experiments seem to constitute experimental verification of Stokes' law for these drops.

4. Positively charged drops of water and alcohol are found by direct measurement to carry charges which are multiples of 4.65×10^{-10}, and all of the multiples from 2 to 6 inclusive have been obtained.

5. The mean of the five most reliable determinations of e is 4.69×10^{-10}. The corresponding value of n (the number of molecules in 1 cubic cm. of gas at 0° C., 76 cm. pressure) is 2.76×10^{19}: that of N (the number of molecules in a gram-molecule) is 6.18×10^{23}; that of eta ($= 3/2$ RT/N, the kinetic energy of agitation in ergs of a molecule at 0° C., 76 cm. pressure) is 2.01×10^{-16}; that of m (the mass in grams of an atom of hydrogen) is 1.62×10^{-24}.

Vitamin B_{12} Promising in Anemia

► HOPE THAT a vitamin may remedy the spinal cord complication of pernicious anemia appears in results of research by Drs. Tom Spies and Robert E. Stone of Northwestern University Medical School.

The vitamin, B_{12}, has been recently isolated and is still hard to obtain. The amount available is so small that complete evaluation of its effectiveness cannot yet be made and the studies are still going on.

So far Drs. Spies and Stone have been able to treat only seven patients with it. But in all seven symptoms improved and some of the abnormal physical findings were reversed.

The condition for which this vitamin shows promise is known medically as subacute combined degeneration of the spinal cord. Symptoms include pain, tingling and numbness.

Donora Disaster Showed Lack of Federal Assistance Authorization

Industrial Smog National Problem

➤ HERE'S A national health protection job for the new Congress and the administration: A clean-up of the air in industrial areas, so as to prevent another Donora tragedy in which industrial fumes held by fog killed a score of persons and made many others ill.

The Donora town council requested federal aid. But the federal health service cannot move into such situations as rapidly as might be either expected or helpful because it must wait for a request from State Health Departments. In this instance, election-day closing of state offices at Harrisburg, Pa., delayed by at least a day the aid the federal health service can give.

The danger is over in Donora now that the fog has been dispelled, and the same combination of fog and no wind may not happen again in years. Even if it did, the health danger could be largely prevented if the industry spent a good deal of money to prevent release of dangerous fumes into the air.

Donora is not alone in its air pollution danger. Los Angeles residents go about with inflamed eyes and sore throats much of the time because of air pollution from the industries in and around the city. Other industrial regions face much the same problems.

St. Louis is a notable example of a city that cleaned up its air, with resultant health benefits to its citizens. But while many cities have ordinances for control of air pollution and for smoke abatement, almost no state has any such legislation.

The problem is big enough, in the opinion of Dr. J. G. Townsend, head of the industrial hygiene division of the U.S. Public Health Service, to warrant more attention on the federal level.

Dust Clouds Cleanse Air

Man-made clouds of dust may be among the weapons that can be used against the poisonous fumes that can form death-dealing smog.

How clouds of dust can purify air laden with potent droplets of sulfuric acid was described by Drs. H. P. Meissner and H. S. Mickley of the Massachusetts Institute of Technology to a chemical engineering symposium of the American Chemical Society.

The clouds are made up of porous materials such as clay or silica gel. These materials absorb mist which escapes mechanical anti-pollution devices, the scientists explained.

Cyclone towers, settling chambers and sprays are effective in preventing dangerous dust from getting into the atmosphere, but stable substances such as sulfuric acid mist are not captured.

Using a turbulent cloud of dust particles as a filter, 95% of the sulfuric acid mist was removed from the air in a test reported by the scientists.

Although clouds of dust are one form of atmospheric pollution, the dust used as a filter is coarser and less likely to get into the air. In operation

in a factory flue, a small side stream of the dust would be withdrawn as fresh material was added, forming a continuous filter of air bearing hazardous mist.

Because of costs, the new method is not expected to replace older systems except where it has economic advantages.

Fires in Coal-Waste Heaps

There will be less smoke in the western Pennsylvania atmosphere if spontaneous combustion in waste coal heaps can be prevented, and Mellon Institute of Industrial Research is about to seek the solution.

The Western Pennsylvania Coal Operators Association is responsible for the study to be made. It has provided the funds for a fellowship at the institute to conduct the investigation. The fellowship has been filled, and research will start early this year under Dr. William L. Nelson of the Mellon organization.

The studies will embrace the scientific causes, prevention and control of coal-refuse fires. It will seek all factors entering into the problem of the spontaneous combustion of coal-waste, particularly where heaped or piled. Among these are the reactions of coal and inorganic sulfides, especially at low temperatures.

New Non-flammable Hydraulic Fluid

➤ DANGER of fire in an airplane from leaking hydraulic fluids used to operate essential mechanism is practically eliminated by a new non-flammable type fluid revealed by Monsanto Chemical Company in whose laboratories it was developed.

This new hydraulic fluid, to be known as Skydrol, is an ester base and contains no halogenated hydrocarbons, salts or water. Chemically, it is virtually inert. It will not attack the structural metals used in an airplane. It is a stable organic compound, highly resistant to aeration oxidation. In addition, it has high lubricating power.

The hydraulic system of an airplane is operated by pumps, and develops high pressures at high flow rates upward of 3,000 pounds per square inch. The fluid is used to activate the mechanism that controls such devices as retractable landing gear, brakes, wing flaps and even windshield wipers.

It must be oily to lubricate the rapidly moving parts of the pumps, and non-corrosive to avoid attacking the various metals in the hydraulic system. Also it must not undergo undue thinning at high temperatures and thickening at low temperatures. It should have low specific gravity to avoid adding undue weight to the plane.

Ordinarily, the hydraulic fluid is completely confined within the hydraulic system, which includes piping extending to many parts of the plane. Occasionally, due in part to the high pressures used, the system springs leaks. A leak causes the fluid to be expelled as a fine spray. If it is flammable, it may catch fire from exhausts, from contact with the hot manifold, or from sparks from the plane's electric system.

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